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Comparison study of upper arm and forearm non-invasive blood pressures in adult Emergency Department patients

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ABSTRACT

Background: Forearm blood pressures have been suggested as an alternative site to measure blood pressures when the upper arm is unavailable. However there is little evidence utilising clinical populations to support this substitution.
Objectives: To determine agreement between blood pressures measured in the left upper arm and forearm using a singular oscillometric non-invasive device in adult Emergency Department patients. The secondary objective was to explore the relationship of blood pressure differences with age, sex, ethnicity, smoking history and obesity.
Design: Single centre comparison study.
Setting: Adult Emergency Department, Tertiary Trauma Centre.
Participants: Forty-four participants who met inclusion/exclusion criteria selected sequentially from the Emergency Department arrival board.
Methods: A random assignment of order of measurement for left upper arm and forearm blood pressures was utilised. Participants were eligible if they were aged 18 years or older, had been assigned an Australasian Triage Scale code of 2, 3, 4, or 5, were able to consent, and able to have blood pressures measured on their left arm whilst lying at a 45° angle. The Bland–Altman method of statistical analysis was used, with the level of agreement for clinical acceptability for the systolic, diastolic and mean arterial pressure defined as ±10 mmHg.
Results: The forearm measure overestimated systolic (mean difference 2.2 mmHg, 95% limits of agreement ±19 mmHg), diastolic (mean difference 3.4 mmHg, 95% limits of agreement ±14.4 mmHg), and mean arterial pressures (mean difference 4.1 mmHg, 95% limits of agreement ±13.7 mmHg). The systolic measure was not significantly different from zero. Evidence of better agreement was found with upper arm/forearm systolic measures below 140 mmHg compared to systolic measures above 140 mmHg using the Levene's test ($p = 0.002$, F-statistic = 11.09). Blood pressure disparity was not associated with participant characteristics.
Conclusions: Forearm measures cannot routinely replace upper arm measures for blood pressure measurement. If the clinical picture requires use of forearm blood pressure, the potential variance from an upper arm measure is ±19 mmHg for systolic pressure, although the variability may be close to ±10 mmHg if the systolic blood pressure is below 140 mmHg.

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What is already known about the topic?

- The gold standard for a non-invasive blood pressure measurement is auscultation of the upper arm at heart level.
- Previous studies recommend substituting forearm blood pressure measures for upper arm measures when clinically necessary.
- Agreement between the two measures has not been established.
- Previous studies have not always used appropriate analytical methods or used clinical populations that can be generalised to the acute adult patient in Emergency Department.

What this paper adds

- Forearm measures cannot be routinely substituted for upper arm measures of blood pressure in Emergency Department patients due to clinical unacceptable variability.
- This is the first study to report evidence of better agreement between upper arm and forearm systolic measures below 140 mmHg.

1. Introduction

Blood pressure measurements provide essential baseline cardiovascular information and reflect a patient's response to medications, intravenous fluids, and other acute treatments. In an Emergency Department, treatment decisions are contingent upon the clinical scenario, systolic blood pressure trends and other related information. Accuracy and speed in obtaining a blood pressure can be imperative, but obtaining blood pressure measurements presents a challenge when the upper arm is inaccessible due to injury, disease process or when the upper arm is too large for the standard range of blood pressure cuffs. Guidelines have suggested the forearm be used when the upper arm is unavailable. These guidelines also identify the need for studies to validate this practice (O'Brien et al., 2003; Pickering et al., 2005).

The evidence supporting the practice of using the forearm alternate is somewhat equivocal. Most studies suggest that there are statistically significant differences between upper and forearm blood pressure measurements and that the measures cannot be used interchangeably (Domiano et al., 2008; Emerick, 2002; Fortune et al., 2008; Palatini et al., 2004; Pierin et al., 2004; Schell and Waterhouse, 2007; Schell et al., 2005, 2006, 2007, 2010; Singer et al., 1999; Tachovsky, 1985). However, measurement of blood pressure and analysis of results have varied across studies. Earlier studies used auscultatory sphygmomanometer (Palatini et al., 2004; Tachovsky, 1985), utilised non-invasive wrist devices (Emerick, 2002; Palatini et al., 2004), measured with different devices between sites (Palatini et al., 2004), did not state validation of their device (Fortune et al., 2008) or did not measure inter-rater reliability when more than one researcher was utilised (Domiano et al., 2008; Palatini et al., 2004). Others did not measure the site circumference and used variable or unspecified cuff size and or site positions. (Domiano et al., 2008; Fortune et al., 2008; Palatini et al., 2004; Pierin et al., 2004; Tachovsky, 1985). Some studies used different anatomical patient positions ranging in degrees between lying to sitting (Domiano et al., 2008; Emerick, 2002; Fortune et al., 2008; Palatini et al., 2004; Pierin et al., 2004; Schell and Waterhouse, 2007; Schell et al., 2005, 2006, 2007, 2010; Singer et al., 1999; Tachovsky, 1985). A number of studies also did not use the Bland–Altman method (Domiano et al., 2008; Fortune et al., 2008; Pierin et al., 2004; Singer et al., 1999; Tachovsky, 1985), the accepted statistical analysis for determining agreement between two measures (Preiss and Fisher, 2008). The majority of studies used healthy volunteers with a high proportion of non-obese white American females being recruited rather than clinical populations so may not be generalisable to unwell Emergency Department patients with multi-ethnic backgrounds (Domiano et al., 2008; Emerick, 2002; Fortune et al., 2008; Schell and Waterhouse, 2007; Schell et al., 2007; Tachovsky, 1985). In addition, the majority of quality studies conducted on blood pressure measurement comparison between the upper arm and forearm have been completed by the same lead investigator K.A. Schell (Schell and Waterhouse, 2007; Schell et al., 2005, 2006, 2007, 2010).

The objective of this study was to assess agreement between the systolic blood pressures as measured on the left upper arm and forearm using the same non-invasive blood pressure oscillometric device designed for upper arm measures in a clinical adult population presenting to an Emergency Department. This study used a computer generated random sequence with a block sequence size of two blinded to the investigator, a single validated electronic oscillometric non-invasive blood pressure device, appropriate cuff sizes based on forearm and upper arm measurements, accurate measured placement for position of cuff and adhered to guidelines for blood pressure measurement by Pickering et al. (2005). The Bland–Altman-method was used for statistical analysis (Bland and Altman, 1986). This study also sampled a more varied clinical Emergency Department population than previously researched.

2. Methods

The Adult Emergency Department Blood Pressure (AEDBP) study was a single centre, prospective comparison study. The aim of this study was to determine the agreement between a single left upper arm and forearm blood pressure obtained in Adult Emergency Department (AED) presentations using the same oscillometric non-invasive electronic device dedicated to obtaining standard upper arm measures to reflect current clinical practice at the study site. Singular blood pressure measures were undertaken and a randomised cross-over order of measurement was used to mitigate normal physiological variation for singular blood pressure measures. The level of agreement for clinical acceptability for this study was defined as ± 10 mmHg by the Adult Emergency Research Group (AERG). The variability of ± 10 mmHg was considered as unlikely to change acute clinical management in adult

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