AUSTRALASIAN JOURNAL OF PARAMEDICINE

PARAMEDICS AUSTRALASIA

Research

Agreement between student paramedics when measuring blood pressure

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https://doi.org/10.33151/ajp.16.630

Abstract

Introduction
Blood pressure (BP) measurement is a core vital sign used by paramedics during patient examination. Throughout the out-of-hospital phase of the patient journey, several paramedics at multiple time-points may measure the BP of a single patient. An understanding of agreement in measurement of BP between paramedics may inform the reliability of serial vital signs and trends arising subsequently. The aims of this study were to assess agreement in BP when measured by student paramedics on healthy volunteers, and to validate teaching methods in an undergraduate paramedicine program.

Methods
A prospective observational design was used to investigate agreement between student paramedics. Pairs of students simultaneously auscultated BP using a dual-head stethoscope, resulting in 40 pairs of systolic and diastolic measurements. Differences in measurements were assessed using paired T-tests. Agreement was assessed using Bland Altman plot analysis and intra-class correlation (ICC).

Results
There were no significant differences between measurements for SBP (-1.1 mmHg, 95% CI -3.77–1.57; p=0.41) or DBP (1 mmHg, 95% CI -1.67–3.67; p=0.45). Regarding agreement, Bland Altman analysis showed a mean difference of 1.1 mmHg (95% limits of agreement -17.44–15.24) and 1 mmHg (95% limits of agreement -15.11–17.12) for SBP and DBP, respectively. ICC agreement was excellent for SBP (ICC 0.92; 95% CI 0.85–0.96) and good for DBP (ICC 0.82; 95% CI 0.65–0.90).

Conclusion
This study of student paramedic measurement of BP indicates there are high levels of agreement when measured concurrently by pairs of students, and validates the teaching methods used at the host university program.

Keywords:
blood pressure; paramedic; agreement; student

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Introduction

Blood pressure (BP) constitutes an important part of the physiological assessment conducted by paramedics on patients in the out-of-hospital setting (1). Measurement of BP is a core component of the secondary survey, and when analysed in conjunction with core vital signs such as heart rate, respiratory rate, level of consciousness and glucometry, provides a dynamic snapshot of acute haemodynamic status. Serial BP measurement over time can also be used to identify trends in physiologic function throughout the out-of-hospital care phase.

While in-hospital settings have ready and available access to automatic non-invasive BP monitoring, manual measurement of BP using aneroid sphygmomanometers remains common in paramedic systems. Over the course of management provided to a single patient, serial manual BP measurements may be taken by several paramedics in order to establish a trend in haemodynamic deterioration or improvement. Therefore, an understanding of the measurement agreement between paramedics when assessing BP is important considering a trend in BP values may be the result of serial measurements performed by more than one paramedic.

Effective manual measurement of BP can be confounded by several key factors including the quality of equipment (aneroid sphygmomanometer and stethoscope) (2); environment in which the BP is being measured (2,3); patient-based factors such as large patients or those unable to remain still and compliant (4); technique of performing the measurement (4); correct sizing and placement of BP cuff (5); and ability to correctly identify the Korotkoff sounds (KS) when auscultating (4). While all are important, the ability to correctly identify the KS is the end-point that enables a measurement to be recorded, though the validity of that measurement will be impacted by the other factors described. Even if the environment, equipment, patient and technique are optimal, inability to accurately identify KS will render the measurement clinically useless.

The body of evidence investigating paramedic or student paramedic ability to measure BP is limited. A 2015 study by Cienki et al compared agreement between BP recorded by paramedics before arrival at hospital and BP taken by ‘expert’ measurers in the emergency department, finding a ‘smaller than expected’ difference and a predisposition among paramedics for terminal digital preference (1). In 2014, Boyle et al conducted a simulation-based study investigating accuracy in BP measurement between student paramedics and a simulated BP value on a manikin’s arm, reporting poor accuracy (6). DuField investigated the impact of ambient noise and stethoscope quality in an observational study of paramedic BP compared to non-invasive automatic BP monitoring and found stethoscope quality did not impact on accuracy compared to the gold standard automatic measurement (2). None of these explicitly investigated BP agreement between student paramedics, and none explored agreement in identification of KS on human volunteers or manikins. Although paramedics continue to learn and refine practice in their postgraduate practice, the teaching and education received in their formative undergraduate training years significantly impacts future clinical performance. Hence, ensuring that student paramedics can correctly identify KS in a controlled non-clinical environment is essential as lead-in to BP measurement in the more challenging and confounding ‘live’ clinical setting. Undergraduate paramedicine programs should therefore engage in quality assessment of teaching and learning strategies to inform teaching methods and delivery of curricula.

Against this background, this prospective observational study aimed to 1) determine agreement in KS identification between student paramedics; and 2) validate teaching methods in an undergraduate paramedicine university program.

Methods

Design and setting

This study utilised a clinical agreement study design and was conducted at Western Sydney University, Australia between June and December 2015.

Participants

Participants were second-year students in an undergraduate paramedicine university program; all were 18 years of age or more. All participants had completed coursework, theoretical and practical education in acquisition of manual BP, and completed 1 month of emergency ambulance clinical placement.

Recruitment and sample size

Participants were recruited via social media platforms, posters and snowballing recruitment. As participants were currently studying under academics who were investigators for the study, an ‘arm’s length’ recruitment approach was used to remove any perception of students feeling pressured or coerced to participate. The academics therefore played no role in recruiting student participants.

As the study was a feasibility pilot study to test study design and process, no a priori formal sample size calculations were made, however a pragmatic target of 30 paired measurements was set to ensure valid statistical analysis using standard t-tests as described in the following sections.

Study outcomes

The primary outcome was mean level of agreement between student participant pairs. The secondary outcome was mean difference in BP between concurrent measurements of systolic and diastolic BP taken by student participants.

Study process and data collection

Participants were required to provide informed consent to participate in the study before engaging in any research activity. Participants were then allocated a partner participant using a non-randomised, convenience allocation approach. The data collection process is illustrated in Figure 1. Each pair was required to sit on chairs separated by a partition, preventing participants from having any visual contact with the other. A research assistant sitting in front of them then manually inflated an aneroid sphygmomanometer connected to a healthy volunteer student. Two participants listened for KS simultaneously using a double-headed stethoscope while watching the dial of the sphygmomanometer. Each participant confirmed they could hear KS during a pilot run before the actual study measurement being taken. Following that confirmation, the research assistant palpated the systolic BP manually to achieve an approximate systolic value. The research assistant then placed the bell of the double-headed stethoscope on the healthy volunteer's arm in the correct position over the brachial artery. The sphygmomanometer was inflated to 30 mmHg past the approximate systolic value, before being slowly deflated at approximately 2 mmHg per second in line with accepted procedures for manual BP auscultation. The gauge of the sphygmomanometer was positioned in front of the participants so both could visualise the gauge needle and numerical values. As both participants listened and watched the gauge, the cuff was deflated until the pressure was 0 mmHg. Each participant was then required to record the systolic and diastolic BP as they measured it on a data collection sheet without communicating with their partner participant. The two data sheets were paired up and entered into a spreadsheet later by the research assistant.

Data analysis

Paired data from measurements taken concurrently by the pairs of participants were subjected to three analyses to robustly test agreement. First, the mean measurements (diastolic and systolic) across all 40 trials were compared using paired t-tests to produce mean difference measured in millimetres of mercury (mmHg) with 95% confidence intervals (95% CI); second, agreement between paired participants was assessed using Bland Altman plot analysis to produce mean; third, agreement was tested using ICC to produce a coefficient with 95% CI. Analyses were conducted using Stata version 13**.**

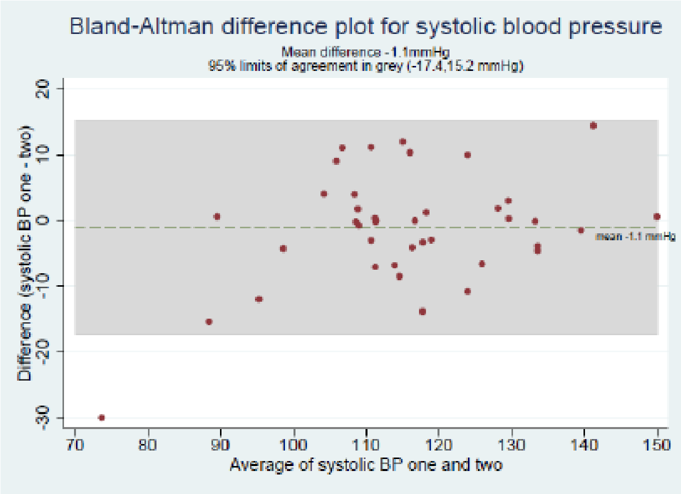
Ethics approval

Approval to conduct the study was granted by the Western Sydney University Human Research Ethics Committee (H10937).

Results

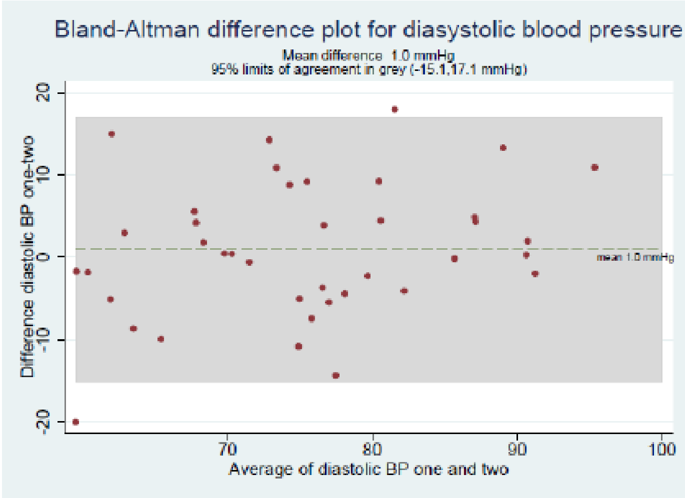
The study attracted 33 student participants during the recruitment period. From this pool of participants, 40 paired measurements were created. Some participants participated in more than one trial, but never with the same partner participant. The t-test for the mean difference in systolic BP across 40 student pairs showed an average difference of 1.1 mmHg (95% CI -3.77–1.57, p=0.41) This result was confirmed by the Bland Altman analysis (Figure 2), which revealed a mean difference of 1.1 mmHg (95% limits of agreement -17.44–15.24) in systolic BP when comparing the measurements of the participant pairs.

Figure 1: Data collection process for gathering simultaneous BP measurements (note the partition between participants)



*5 data points not visible due to doubling up of values

Figure 2. Bland-Altman plot of systolic BP agreement between student one and two (n=40* paired trials)



*3 data points not visible due to identical values

Figure 3. Bland-Altman plot of diastolic BP agreement between student one and two (n=40* paired 'trials')

For agreement in diastolic BP, the mean difference was 1 mmHg (95% CI -1.67–3.67; p= 0.45). This again suggested that there is no statistical nor clinical difference between the systolic BP measurements between students one and two over the 40 trials. This result was confirmed by the Bland Altman analysis (Figure 3), which revealed a mean difference of 1 mmHg (95% limits of agreement -15.11–17.12) in diastolic BP when comparing the measurements of student one to student two.

For the agreement between students using ICC, agreement was excellent for systolic BP (ICC 0.92; 95% CI 0.85–0.96), and good for diastolic BP (ICC 0.82; 95% CI 0.65–0.90).

Discussion

Student paramedics could correctly identify KS when BP of healthy volunteers was auscultated in a controlled non-clinical environment. This was evidenced by high levels of agreement confirmed by several methods of analysis.

While these results contained herein found that student paramedics in this cohort can accurately identify KS as demonstrated by high level of agreement between students, the small body of literature describing student measurement of BP suggests this may be a novel finding. In what appears to be the only other study investigating quality of BP measurement in the context of student paramedics, Boyle et al found that final year students in an Australian undergraduate program had poor accuracy when measuring in a simulated setting (6). In that study, 26 students performed the BP measurement procedure on a simulation manikin capable of simulating an auscultatable BP. A 'true' BP was programmed into the manikin, serving as the 'gold standard' against which student measurements were compared. Poor accuracy was reported for high, low and normal range BPs for both systolic and diastolic measures. No specific reference was made in that paper to identification of KS, however given the controlled simulated context, it is reasonable to hypothesise that inability to correctly identify simulated audible KS may have contributed to the result. It should be noted that the study designs were different, with Boyle et al testing accuracy against a 'true' value, while the present study investigated level of agreement between operators. Further, the students in the present study did not perform the whole procedure, hence restricting interpretation to identification of KS.

Away from the specific student paramedic context, student measurement of BP has been investigated in a small number of studies using students from various clinical health disciplines, predominantly nursing and medicine. Gonzalez-Lopez et al studied nursing and medical student knowledge relating to performance of BP measurement, finding poor theoretical knowledge which it was suggested would negatively impact on effectiveness of measurement (7). Similarly poor knowledge was reported by Torrance et al, who conducted a 20 question survey of 78 nursing students in 1996. They reported major deficits in related theoretical and procedural knowledge, with 90% having not heard of Korotkoff sounds or auscultatory gap (8). In an associated observational study involving student nurse measurement of BP during mock situations, Torrance et al reported 'little' compliance with established guidelines for BP measurement (9), while an Iranian study of 350 nursing students concluded that the knowledge of participants appeared inadequate to perform BP measurement in a standardised manner. Less than optimal ability to measure BP was reported in a large US study in 2015, in which 159 medical students from multiple institutions were assessed against an 11-point skill set for BP measurement performance; only one student properly performed all 11 elements, while the mean for the group was 4.1 successfully performed elements (10).

Given the consistency of findings suggesting less than optimal capacity to effectively perform BP measurement across students of other disciplines, it would be naive to assume these deficiencies are not present in undergraduate paramedic training programs. The findings of the present study, while limited to assessment of ability to accurately identify KS with good agreement between students, does however stand in general contrast to results from the other disciplines. This could be interpreted as validation of the teaching methods and strategy this undergraduate program uses to teach this important aspect of the BP measurement procedure (that being awareness and identification of KS).

The poor understanding of BP measurement across students from different backgrounds raises questions. Measurement of BP is a fundamental clinical investigation that is routinely performed by health professionals including paramedics. It is performed as a means to establish a sense of physiological function either as an initial 'snapshot' during a primary survey, or as a serial observation used to chart the course of a patient's clinical trajectory over time. It is of indisputable importance. There is no clear answer to the question, however we hypothesise that among the many diverse procedures performed by paramedics and other health professionals, it could be that BP measurement may be perceived to be a very basic procedure in need of minimal attention. Such a perception could exist in the eyes of students focussed on what they believe to be more important or advanced procedures, but it could also exist, subconsciously or otherwise, in the eyes of academic staff, leading to a 'hidden curriculum' that understates the importance of core vital signs such as BP measurement while overvaluing other aspects of practice. A similar conclusion has been voiced in the context of medical students, where Rakotz et al concluded that curriculum changes should be implemented that prioritise simple but important aspects of assessment such as BP measurement, and that an emphasis on achieving and maintaining proficiency be introduced (10). Undergraduate clinical health discipline programs, including paramedicine, could be well served by reviewing the way in which basic assessments such as BP measurement are taught in the first instance, and how these basic procedures are consolidated and maintained across the duration of university education.

Limitations

These data should be considered in light of several limitations. The study participants were second-year paramedicine students in an undergraduate university program; attempts to extrapolate these findings to qualified paramedics or students in non-university paramedic training programs may be misleading. The study was conducted in a non-clinical, controlled environment. This is not so much a limitation but rather a feature of the study design, which intentionally sought to remove other potential confounders that might affect measurement of BP, thus isolating identification of KS as the key determinant of agreement. Agreement may be different if the measurer performed all aspects of the procedure themselves, bringing procedural technique into the equation. Therefore, the context of the study must be about identification of KS rather than BP measurement as a complete procedure. Volunteers on whom BP was measured were all young, healthy and at rest at time of measurement, hence all measurements were within physiologically normal ranges. Agreement between measurers may be different for unusually high or low BPs as might be found in a clinical context.

Conclusion

This study of student paramedic measurement of BP indicates there are high levels of agreement when measured concurrently by pairs of students. This result validates the teaching methods used at the host university program, and is encouraging for students entering into clinical practice.

Acknowledgements

This research is an output of the Undergraduate Paramedicine Student Research Engagement Academy (UPSTREAM) initiative at Western Sydney University, and was funded by a grant from the Cultivation of Innovative Teaching and Learning (CILT) program. The authors would like to thank the students of Western Sydney University for their support of the study. The authors would like to thank Francois Fouche for providing biostatistical support and data analysis.

Conflict of interest

The authors declare they have no competing interests. Each author of this paper has completed the ICMJE conflict of interest statement.

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