Research

Accuracy of student paramedics when measuring adult respiratory rate: a pilot study

Sarah Galka BMedSc, BHSc(Paramedicine) is a qualified paramedic[1]; Jessica Berrell BHSc(Paramedicine) is a qualified paramedic[1]; Rami Fezai BMedSc, BHSc(Paramedicine) is a qualified paramedic[1]; Louis Shabella BMedSc, BHSc(Paramedicine) is a qualified paramedic[1]; Paul Simpson PhD, MScM(ClinEpi), GCClinEd, GCPaeds, BEd BHSc(PrehospCare), AdvDipParaScience, ICP is Senior Lecturer and Director of Academic Program (Paramedicine)[1]; Liz Thyer PhD, BSc(Hons), DipAmbParaScience, GCTE is Senior Lecturer in Paramedicine[1]

Affiliation:
[1]School of Science and Health, Western Sydney University, New South Wales

Abstract

Introduction
Abnormal respiration rate (RR) is commonly undervalued in the out-of-hospital environment despite its use as a predictive marker for physiological decline. The need for paramedicine students to manually measure RR is therefore important. The aims of the study were: 1) to determine the accuracy of manually measured RR when performed by second-year paramedicine students on healthy volunteers in a simulated environment; and 2) to provide data to inform design of a larger study.

Methods
This pilot study utilised a prospective double-blinded observational design, in which neither the participants nor the healthy volunteers knew the specific aim of the study. Paramedicine students manually recorded RR along with a range of vital signs including non-invasive manual blood pressure, heart rate, oxygen saturation, temperature and 4-lead electrocardiogram on healthy volunteers. Capnography was used as the gold standard to confirm observed respiratory rates. Intra-class correlation was used to assess agreement between manual RR and capnography.

Results
Thirty-six complete sets of data were recorded. There was strong agreement between paramedicine student and capnography measurements (ICC 0.77; 95% CI 0.54–0.88). Accuracy of paramedicine students to measure RR of the opposite gender showed no statistical difference when female students (F=0.05, p=0.83) or male students (F=0.04, p=0.84) measured.

Conclusion
The manual RR measured by paramedicine students agreed well with capnography irrespective of the gender of the patient or paramedicine student. These data suggest the two measurements could be used interchangeably, although the difference between statistical and clinical significance should be further investigated.

Keywords:
emergency medical technician; respiratory rate; undergraduate medical education

Corresponding Author: Liz Thyer, e.thyer@westernsydney.edu.au

Introduction

Accuracy of components of vital sign assessments conducted by clinical health students have been previously documented, however minimal research focusses on paramedicine students (1,2). Given the uncontrolled nature of the paramedicine environment and early intervention with patients, it is essential that assessments are robust and accurate. In the out-of-hospital setting, it is common practice for paramedics to undertake a full set of vital signs: non-invasive blood pressure (NIBP), tympanic temperature (temp) heart rate (HR), oxygen saturation (SpO2) and 4-lead electrocardiogram (ECG) without the aid of automated machines. Access to automated physiological measurement instruments is variable and heavily dependent on the infrastructure of individual organisations. In most settings, advanced diagnostic adjuncts such as capnography or transthoracic impedance plethysmography are not available in the out-of-hospital environment (3), so manual assessment of RR remains relevant.

Substantial research suggests that alterations in vital signs can act as an early warning indicator for patient change, signifying importance of early detection in emergency medicine (4-7). Respiration rate in particular is a noted marker of physiological decline, although it is commonly referred to as the 'neglected' or 'forgotten' vital sign and is often undervalued and not recorded (7-10). This emphasises the importance of paramedicine students' understanding of the significance of abnormal RR, and ability to efficiently and accurately measure them.

Against this background, the aim of the study was: 1) to determine the accuracy of manually measured RR when taken by second-year paramedicine students on healthy volunteers in a simulated environment; and 2) to provide data to inform design of a larger study.

Methods

Study design
This pilot study utilised a prospective double-blinded observational design.

Setting
The study was conducted at Western Sydney University (New South Wales, Australia) in a simulated setting. Data were collected between April and July 2015.

Participants
Participants were staff and students of Western Sydney University who, after consenting to participate in the study, were allocated to one of two groups depending on exclusion criteria. The first group were paramedicine students who had completed their first year of study and passed an exam relating to correct conduct of a vital sign assessment (HR via radial pulse, NIBP, temp, ECG and RR). The second group (simulated patients) were other undergraduate health students and staff who declared they were healthy and not taking any medication (other than the contraceptive pill if female). All participants remained unaware as to the true specific interest in respiratory rate until completion of the study.

Procedures
When measuring respiration, patients may alter their breathing pattern if they are aware of being assessed. In order to address this barrier, paramedicine students conducted a full set of vital signs on the healthy volunteers, comprising of NIBP, tympanic temp, HR, SpO2 and 4-lead ECG. Both the paramedicine students and simulated patients were blinded to the specific aims of the study and the simulated patients not specifically advised when the RR was being measured. Results were compared to control (machine measured) values, however only RR was recorded. The student-measured RR was compared to the 'gold standard': a recorded value via simultaneous Lifepak 15™ capnography. The monitor was positioned in such way that neither the paramedicine students nor simulated patient could view the screen.

Before commencement of data collection, two quantitative surveys were completed, one for the paramedicine students and one for the simulated patients. The surveys collected information relating to age and gender. The paramedicine students were also asked about previous first aid training and experience (eg. volunteer work with St John Ambulance or current first aid certificate). The simulated patients recorded whether they identified as being healthy by noting no previously diagnosed respiratory or physical conditions that would interfere with a short period of mild exercise and not taking any medication (except the contraceptive pill in females).

The surveys also acted as a means of sorting participants into alphanumerical categories that would later correlate with result identification.

Outcome measures
The primary outcome for the study was RR, measured manually by paramedicine students and via simultaneous capnography for the control measure. Secondary outcomes were: the accuracy of respiratory rate measurement in non-distressed patients as well as those with increased respiratory demand following mild exertion of the simulated patient and; due to the need to look at a patient's chest during manual RR measurement, accuracy of paramedicine students of a particular gender to measure patients of the opposite gender.

Data analysis

Quantitative data was stored using SPSS/PC software and subjected to descriptive statistical analysis.

For the outcome of accuracy compared to the control measure, a one-way ANOVA inter-correlation class test that identified variances in gender related treatment was performed. A two-tailed t-test was used to identify any statistical variances or trends in the measurement of RR stratified in gender groups. Bartlett's test was performed to determine equal variances and to identify any ANOVA assumptions. The intra-class correlation (ICC) was used to determine if there was an agreement between the manual RR and capnography. Finally, a Bland-Altman plot was used to further identify and explore any differences in data.

Ethics approval

Western Sydney University Human Research Ethics Committee provided ethics approval (approval number H10990).

Results

Thirty-six complete sets of data (pre- and post-exercise RR with manual measurement and capnography) were recorded. An even gender split was achieved in the simulated patients, while 42% of paramedicine students were male. The median age range of the paramedicine students and simulated patients was 18 to 23 years of age with a range of 18 to 30+ years for both groups.

Manual versus capnography
Overall, ICC agreement between manual RR and capnography showed strong agreement (ICC 0.77; 95% CI 0.54–0.88). This finding was supported by Bland-Altman plots that indicated a mean difference of 0.11 breaths between student measured (mean=17.53, SD=3.89) and capnography (mean=17.42, SD=3.59). Two outliers were noted where there was significantly greater variation between manual and capnography measured RR.

Pre- and post-exercise RR
In relation to the pre- and post-exercise data, two results were obtained. The first related to the agreement between manual RR and capnography and the second to the change in RR (when measured manually) in the pre- and post-exercise groups. The manual and capnography RR were compared for the pre- and post-exercise groups and was found to have a 95% limit of agreement of -6.2 to 6.4 breaths, indicating that there was good agreement between the two measurements (Figure 1).

Implementation of a short exercise routine to increase physiological activity and provide a varying RR resulted in a statistically significant difference when measured manually (t=-2.7, p=0.01); the pre-exercise group had a mean RR of 16.75 (SD=4.6) compared to 18.3 (SD=3.87) for the post-exercise group.

Gender
A one-way stratified ANOVA showed no statistical difference in RR when measured by female (F=0.05, p=0.83) or male students (F=0.04, p=0.84) (Figure 2).
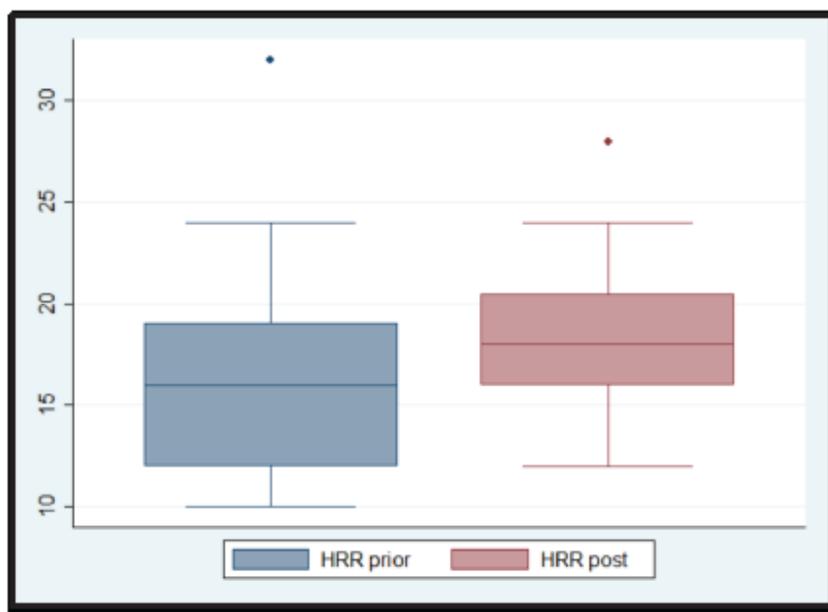

Figure 1. Difference in manual and capnography RR in the pre (HRR prior) and post (HRR post) exercise groups

Discussion

The data presented provides new information relating to measurement of RR by Western Sydney University paramedicine students, suggesting that in this sample, RR is accurately measured and reported. To our knowledge, this finding has not been reported elsewhere in the context of students in any health discipline or in prospective research in clinical settings.

Our finding of good accuracy for manual RR measurement, compared to capnography, added to the existing body of related literature. Previous literature investigating paramedic student accuracy of vital signs is mixed; some studies show a lack of accuracy (1) while others had varied results (11). A 2015 study investigating accuracy of RR measurement of doctors at a London teaching hospital (12) revealed high levels of inaccuracy, especially when assessments were made in short time intervals while a 2015 study of nurses also identified poor accuracy (13). The disparate results may be due to a number of factors including time since training, clinical experience, competing clinical priorities or health status of the subjects being assessed. Our positive results suggest that the teaching methods seem to have been useful for this cohort, nonetheless, the importance of the assessment and variable results warrant further investigation.

Consequences of inaccurately measuring RR rates (in particular, RR below 12 or above 20 breaths/min) may influence clinical decisions and potentially lead to patients being denied preventive treatment or increase risk of mortality (14,15). Such issues contribute to suggestions for RR >25 breaths/min being used as an out-of-hospital triage tool in rural trauma (9). Given only 69 of the 226 ambulance stations run by New South Wales Ambulance are metropolitan (16), the likelihood that paramedicine students will work rurally adds increased need for accuracy in RR measurement.

There was strong statistical agreement between the manual and capnography RR, although this still allowed for a variation of up to 6 breaths per minute, which could be clinically significant for a patient and highlights the need to review results in light of the clinical picture. When considering this clinical picture, the study attempted to mirror respiratory distress, through the exercise intervention. Pre- and post-exercise RR were shown to be statistically significant, however both pre- and post-exercise RR (16.75, SD=4.6 and 18.3, SD=3.87 respectively) fell within the normal respiratory range. Therefore the paramedicine students did not experience having to measure RR on patients who were experiencing extremes of respiratory distress. This relatively small change in post-exercise RR may have been due to the time lag between finishing the exercise routine and taking the repeat RR measurement as the paramedicine students were conducting a vital sign survey in a predetermined order. Alternately it may have been due to the health and relatively young age of the simulated patients.

Although no previous literature appears to have investigated this area, we questioned whether a difference would be apparent between genders given that the manual measurement of RR requires prolonged focus on the patient and the students were novices. No statistical difference between genders was noted when accuracy of RR was analysed. This may be a factor of the small sample size (only five male paramedicine students took RR measurements on female simulated patients).
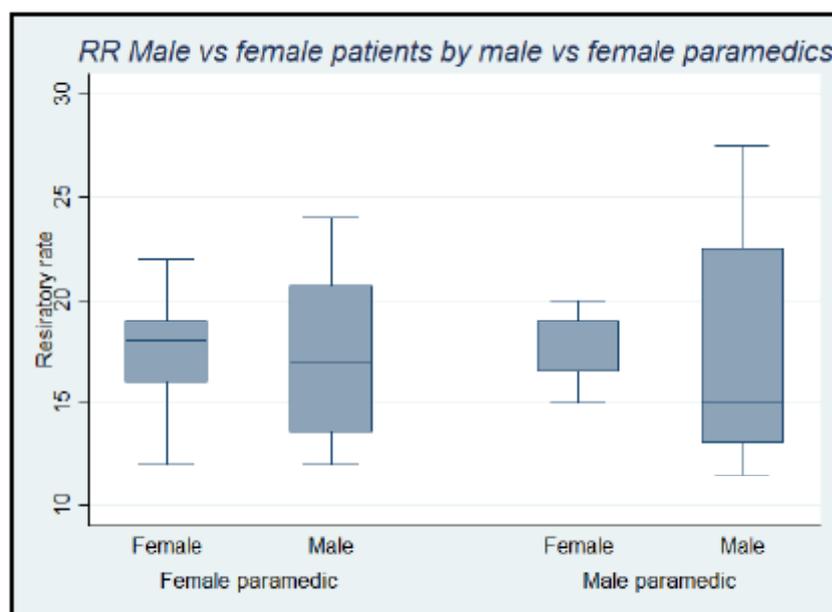

Figure 2. Difference in gender between paramedicine student and healthy volunteer

Alternately the professional demeanour of the paramedicine students when taking RR on a simulated patient may explain this. Lastly, many of the participants from both groups were known to each other and many were part of a small class who had previously undertaken practical tasks together, therefore familiarity may have obviated any difference. Paramedicine students often chose their simulated patient as well, resulting in potential selection bias. Future studies would benefit from a randomisation of the paramedicine students and simulated patients in the study.

While the aim of this study was to determine the accuracy of manually measured RR when taken by second-year paramedicine students on healthy volunteers in a simulated environment, this provides the baseline for a large and more complex study. Future quantitative studies should include students from additional universities and consider comparison of all components of the vital signs survey to investigate variation in results and determine if trends in accuracy become apparent. Additionally, time issues identified by Philip and colleagues (12) indicate greater accuracy when RR is measured over a 1-minute interval in critically ill patients as opposed to 15 or 30 seconds intervals. With this in mind, undertaking a qualitative evaluation of the technique of paramedicine students, their confidence, perceptions and understanding of the importance of RR assessment could valuably contribute to this area.

There are a number of limitations in which the results of this study need to be considered. The 'pilot study' design of this study meant that no formal sample size calculation was performed, and therefore the study remains underpowered and at risk of type II error. The data should be considered hypothesis generating in nature more so than definitive despite statistical significance being reached in primary outcomes. The results will be useful also in the design of a larger, appropriately powered study in the future. Another key limitation was the use of healthy volunteers for the simulated patients and lack of randomisation of paramedicine students to simulated patients. Such an approach was considered beyond the scope of the pilot study and so was not adopted. Finally, the prescribed order the paramedicine students were instructed to use when undertaking the vital signs limited variation, but may also have limited the impact of the exercise period on the RR and may have impacted the normal procedures undertaken by these participants when conducting a vital signs survey.

Conclusion

The manual RR measured by paramedicine students agrees well with capnography, irrespective of the gender of both the paramedicine students and simulated patients. These two measurements could be used interchangeably, although the difference between statistical and clinical significance should be further investigated.

These results suggest teaching and learning methods of Western Sydney University undergraduate paramedicine students for this skill are suitable for the majority of the cohort.

Conflict of interest

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

References

1. Boyle M, Williams B, Sawyer S. The accuracy of undergraduate paramedic students in measuring blood pressure: a pilot study. Australasian Journal of Paramedicine 2014;11(2).
2. Crosley A, Rose J. Knowledge of accurate blood pressure measurement procedures in chiropractic students. J Chiropr Edu 2013;27:152-7.
3. Smith I, Mackay J, Fahrid N, Krucheck D. Respiratory rate measurement: a comparison of methods. British Journal of Healthcare Assistants 2011;5:18-23. Available at: http://dx.doi.org/10.12968/bjha.2011.5.1.18
4. Bristow P, Hillman K, Chey T, et al. Rates of in-hospital arrests, deaths and intensive care admissions: the effect of a medical emergency team. Med J Aust 2000;173:236-40. Available at: www.mja.com.au/journal/2000/173/5/rates-hospital-arrests-deaths-and-intensive-care-admissions-effect-medical
5. Fieselmann J, Hendryx M, Helms C, Wakefield D. Respiratory rate predicts cardiopulmonary arrest for internal medicine inpatients. J Gen Intern Med 1993;8:354-60. Available at: http://dx.doi.org/10.1007/bf02600071
6. Grossman P. Respiration, stress, and cardiovascular function. Psychophysiology 1983; 20:284-300. Available at: http://dx.doi.org/10.1111/j.1469-8986.1983.tb02156.x
7. Smith G, Prytherch D, Schmidt P, et al. Hospital-wide physiological surveillance: a new approach to the early identification and management of the sick patient. Resuscitation 2006;7:19-28. Available at: http://dx.doi.

References (continued)

8. Cretikos M, Bellomo R, Hamilton K, Chen J, Finfer S, Flaboris A. Respiratory rate: the neglected vital sign. Med J Aust 2008;188:657-9. Available at: www.mja.com.au/journal/2008/188/11/respiratory-rate-neglected-vital-sign

9. Husum H, Gilbert M, Wisborg T, Van Heng Y, Murad M. Respiratory rate as a prehospital triage tool in rural trauma. J Trauma 2003;55:466-70.

10. Parkes R. Rate of respiration: the forgotten vital sign. Emerg Nurse 2011;9:12-7.

11. Williams B, Boyle M, O'Meara P. Can undergraduate paramedic students accurately identify lung sounds? Emerg Med J 2009;26:580-2.

12. Philip KE, Pack E, Cambiano V, Rollmann H, Weil S, O'Beirne J. The accuracy of respiratory rate assessment of doctors in a London teaching hospital: a cross sectional study. J Clin Monit Comput 2015;29:455-60.

13. Lovett P, Buchwald J, Sturmann K, Bijur P. The vexatious vital: neither clinical measurements by nurses nor an electronic monitor provides accurate measurements of respiratory rate in triage. Ann Emerg Med 2015;45:68-76.

14. Duckitt R, Buxton-Thomas R, Walker J, et al. Worthing physiological scoring system: derivation and validation of a physiological early-warning system for medical admissions. An observational, population-based single-centre study. Br J Anaesth 2007;98:769-74.

15. Elliott M, Coventry A. Critical care: the eight vital signs of patient monitoring. Br J Nurs 2012;21:621-5. Available at: http://dx.doi.org/10.12968/bjon.2012.21.10.621

16. NSW Government. NSW Ambulance - Ambulance Stations n.d. Available at: www.ambulance.nsw.gov.au/about-us/Map-of-Stations.html