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ORIGINAL ARTICLE

Accuracy of two-rescuer adult CPR performed by medical registrars at a South African university

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ABSTRACT

Background: Cardiopulmonary resuscitation (CPR) is performed to manually keep brain function intact until the patient's spontaneous blood circulation and breathing are restored. In South Africa, registrars, who are qualified doctors training to specialise in a medical field, are usually the team leaders and oversee junior doctors and nurses during resuscitation.

Objectives: This study aimed to determine the accuracy of the execution of two-rescuer adult CPR on a Resusci-Anne® manikin performed by registrars from the University of the Free State, South Africa.

Methods: A cross-sectional study was conducted. From a target population of 142 registrars, 47 participated, of whom 44 were included in the analysis. During five cycles of CPR, compression quality was assessed. During a subsequent five cycles, airway management was assessed. Participants were evaluated executing CPR on the Resusci-Anne® manikin, with a recently Basic Life Support trained student researcher as second rescuer. A modified version of the American Heart Association's tick sheet for two-rescuer adult CPR was completed by two student researchers. Department, gender and the date of the most recent CPR training attended were recorded.

Results: The median total percentage score was 82.2% (range 33.3% to 100.0%). Results showed that 88.6% of registrars consistently demonstrated correct hand placement, 25.0% correct compression rate, 93.2% correct compression depth, and 61.4% allowed complete chest recoil during compressions. Consistently correct E-C technique was found in 77.3%, and correct ventilation rate in 93.2%. Only 63.6% correctly managed an open airway, and 61.4% achieved visible chest rise. A consistently correct compression-to-ventilation ratio was performed by 59.1% of registrars.

Conclusion: The study found that registrars were not consistently performing high-quality CPR on a Resusci-Anne® manikin and identified areas needing attention. The results of this study highlight the need for compulsory CPR training and regular fire drills for registrars.

Introduction

Cardiopulmonary resuscitation (CPR) is performed to manually keep the patient's brain function intact until spontaneous blood circulation and breathing are restored. It is crucial to use caution when performing CPR, as life-threatening injuries can occur during the performance of CPR and the risk of these injuries increase when CPR is not done correctly. Therefore, a healthcare professional should strictly follow the guidelines regarding chest compression rate, chest compression depth, adequate recoil, airway management and adequate ventilation as stipulated by the American Heart Association (AHA) [1].

In many institutions, CPR instruction is led by a trained instructor who can improve trainee skills with feedback and assurance. It is recommended that practise sessions should be distributed over a period of time, using self-training courses and spending time practising CPR on manikins, such as Resusci-Anne® [2].

The quality of CPR procedures and execution is directly related to the memory retention of the rescuer executing the CPR. Basic Life Support (BLS) and CPR courses are mandatory components of the curriculum completed by South African undergraduate medical students. However, it has been shown that shortly after certification, even in healthcare workers, infant and adult CPR skills and execution methods decline [3,4].

A study showed healthcare providers retain information for short periods and that retention over longer periods decreases to some extent.

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However, retention at six months is still significantly higher than the preliminary knowledge [5]. As different healthcare facilities do not all have strategically intervallic mandatory refresher courses, the retention of CPR procedures and execution in many healthcare providers may be of concern.

In South Africa, registrars are qualified doctors who receive training to become specialists in a medical field. At the University of the Free State (UFS), registrars train for 4 or 5 years to specialise in various surgical and medical specialities. Registrars are usually the team leaders and oversee junior doctors and nurses during resuscitation. It is expected that registrars should attain a high total score as they are BLS certified and may regularly be confronted with situations requiring CPR. Regular refresher BLS and advanced trauma life support (ATLS) courses are available at the UFS.

The study aimed to determine the accuracy of two-rescuer adult CPR performed by registrars of the Faculty of Health Sciences at the UFS in Bloemfontein, South Africa.

The specific objectives were to:

- Assess whether registrars perform good quality compressions and can manage an open airway and adequate ventilations using a bag valve masque during CPR on a Resusci-Anne® manikin.
- Identify any problem areas during CPR execution by registrars of different departments.
- Determine when the participants last attended a training course in CPR.
- Identify any correlation between the time elapsed since the participants' last CPR training course and their current performance.

Methods

Study design and population

A cross-sectional study was conducted between July 2016 and November 2016. The study population included all registrars of clinical departments at the Faculty of Health Sciences, UFS, who dealt with adult patients. Departments with 10 or fewer registrars, non-clinical departments and paediatric departments were excluded from the study. Thus 21 of 28 departments and 104 of 246 registrars were excluded.

Registrars from the following seven departments were considered for inclusion: Anaesthesiology, Diagnostic Radiology, Family Medicine, Internal Medicine, Obstetrics and Gynaecology, Orthopaedic Surgery, and Surgery. These 142 registrars worked at the Universitas Academic Complex in Bloemfontein during the study period. Convenience sampling was used for this study. Registrars who refused to participate or who withdrew from the study were excluded.

Procedures

In preparation for the study, the five student researchers and a fellow medical student as field worker completed the Basic Life Support (BLS) course, as facilitated by the Clinical Simulation Unit of the School of Medicine, UFS. This was to ensure the standardisation of the researchers, adding to the validity and reliability of the study.

A complete list of the registrar names and their respective departments was obtained from the Postgraduate Administration Office. Meetings were arranged with the heads of the departments during which the study was explained, but only in broad terms. This was an effort to minimise preparation done by registrars before the evaluation.

A modified version of the AHA's tick sheet [6] for two-rescuer adult CPR was used. Participants were evaluated using the Resusci-Anne® manikin to perform two rounds - one round to evaluate compression quality and one round to evaluate airway management and ventilation - of the designated five cycles of two-rescuer CPR. The participant's department, gender and the date of the most recent CPR training attended were recorded on the tick sheet.

Nine criteria, sub-sectioned to *compression quality* (hand placement, compression rate, compression depth and chest recoil) and *airway management and ventilation* (ventilation rate, E-C clamp, airway opened, chest rise and compression-to-ventilation ratio), were each awarded a maximum of five marks per round, with a potential total performance score of 45 marks. Each cycle had two options: 1 = correct and 0 = incorrect.

Each participant was informed of the two-rescuer nature of the CPR before the evaluation. The participant received an information leaflet and a consent form. The consent form included a non-disclosure condition with a request to refrain from divulging information about the nature of the assessment to their colleagues or seniors to facilitate an unbiased study.

Before the evaluation, participants answered a theoretical knowledge question about the compression-to-ventilation ratio. If the participant answered incorrectly, the participant was informed of the correct ratio. This was an effort to ensure standardisation.

The equipment needed for the evaluation included two Resusci-Anne® manikins, two bag-masque devices and two knee mats. Two student researchers observed and evaluated the participant's execution of CPR. The third student researcher acted as the second rescuer. During the first round, the participant was responsible for compressions and during the second round for airway management and ventilation. The third student researcher only followed the instructions given by the participant. If the participant could not perform accurate CPR and/or failed to instruct the second rescuer, the second rescuer did not assist the participant.

Pilot study

A pilot study was conducted on five registrars from the Departments of Oncology, Cardiothoracic Surgery and Dermatology. These departments had ten or fewer registrars each and were therefore excluded from the main study. Registrars were selected using convenience sampling.

The pilot study aimed to test the tick sheet's usability and determine whether the logistical and practical arrangements were achievable. After each evaluation, the tick sheets completed by the student researchers for all the participants were compared to standardise the evaluation and limit inter-observer variations. No inter-observer variation was identified. After the pilot study, minor changes were made to the tick sheet.

Data analysis

Results were entered into an Excel spreadsheet. Data were analysed by the Department of Biostatistics, Faculty of Health Sciences, UFS. Results were summarised by frequencies and percentages (categorical variables) or medians and ranges (numerical variables due to skew distributions). Spearman rank correlation coefficient was calculated between the total performance score and time since previous CPR training.

Ethical aspects

The protocol was approved by the Health Sciences Ethics Committee, UFS (HSREC-S 36/2016). Permission to conduct the study was obtained from the Free State Department of Health, the Head of the School of Medicine, the Dean of the Faculty of Health Sciences and the Vice Rector of Research, UFS. The Head of the Clinical Simulation and Skills Unit, Faculty of Health Sciences, UFS, gave permission to use the Unit's manikins and other necessary equipment. Information was handled confidentially. Each participant was assigned a unique number that was recorded on the tick sheet instead of any identifying details.

Results

Of the potential 142 registrars in the seven clinical departments, 47 (33.1%) registrars participated. Due to the low response rate for

Table 1
Departmental representation (n = 44).

Department	**Participants (n)**	**Representation in sample** (%)
Diagnostic Radiology	8	18.2
Family Medicine	8	18.2
Internal Medicine	7	15.9
Obstetrics and Gynaecology	8	18.2
Orthopaedic Surgery	8	18.2
Surgery	5	11.4

Anaesthesiology (3/28, 10.7%), it was decided to only include the registrars of the other six departments in the study, namely 44 of 114 registrars (38.6%). Twelve participants were women (27.3%) and 32 men (72.7%).

Table 1 illustrates the percentage of each department's representation in the sample.

Compression quality

Most participants (93.2%) correctly achieved compression depth for all five cycles, while 88.6% showed the correct hand placement (Table 2). Just over 60% consistently allowed for full chest recoil. Only 25.0% of the participants consistently performed CPR at the correct compression rate, while 27.3% did not correctly manage the compression rate in any of the cycles.

Airway management and ventilation

Most participants (93.2%) correctly managed the ventilation rate. Except for the application of the E-C clamp (77.3%), only around 60% of the participants correctly performed the correct steps for open airway, chest rise and compression-to-ventilation ratio during all five cycles. Compression-to-ventilation ratio had the highest percentage of participants (27.3%) who did not execute this step correctly in any of the cycles.

General performance

Two-thirds of the participants (n = 29, 65.9%) had a total percentage score of ≥ 80.0%. The median total percentage score was 82.2% (range 33.3% to 100.0%).

Most recent CPR course completed

Most participants (n = 37, 84.1%) had completed a CPR course in the previous five years: one year (n = 11, 25.0%), two years (n = 7, 15.9%), three years (n = 6, 13.6%), four years (n = 6, 13.6%) and five years (n = 7, 15.9%). Seven participants (15.9%) reported that it had been between six to 15 years since attending a CPR course.

Correlation between performance and time elapsed since last CPR course

As shown in Fig. 1, there was no correlation (r=−0.06, p = 0.71) between the score achieved and the time since the last CPR training. The highest median total percentage score of 86.7% was achieved by participants whose last CPR course completion took place two years or five years ago. Participants who completed their last CPR course in the past six years or more achieved the lowest median total percentage score of 73.3%.

Discussion

In a recent study in the same setting, less than a quarter of the participating doctors (of whom 56.3% were registrars) had a score of 80%

Table 2
Criteria evaluated during the two-rescuer CPR and the number of participants completing between zero and five cycles correctly (n=44).

		Number of cycles completed correctly					
		0	1	2	3	4	5
Skill	Definition/criteria for high quality CPR execution [6]	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Compression quality							
Hand placement	On lower half of sternum.	3 (6.8)	0	1 (2.3)	1 (2.3)	0	39 (88.6)
Compression rate	Each set of 30 compression completed in 15-18 s (100-120/min)	12 (27.3)	5 (11.4)	6 (13.6)	5 (11.4)	5 (11.4)	11 (25.0)
Compression depth	'Click' sound should be heard at least 23-30 times	2 (4.6)	0	1 (2.3)	0	0	41 (93.2)
Chest recoil	Full chest recoil after compression at least 23-30 times	6 (13.6)	1 (2.3)	2 (6.8)	4 (9.1)	3 (6.8)	27 (61.4)
Ventilation and airway management							
Ventilation rate	Two breaths given with each breath delivered over 1 s in less than 10 s	0	0	0	0	3 (6.8)	41 (93.2)
E-C clamp	Correct seal of ventilation bag and use of E-C clamp	5 (11.4)	1 (2.3)	3 (6.8)	0	1 (2.3)	34 (77.3)
Airway opened	One hand on forehead, opposite thumb slightly depressing chin, without hyperextension of the neck	3 (6.8)	2 (4.6)	4 (9.1)	3 (6.8)	4 (9.1)	28 (63.6)
Chest rise	Visible	5 (11.4)	2 (4.6)	2 (4.6)	3 (6.8)	5 (11.4)	27 (61.4)
Compression-to-ventilation ratio	30 compressions to two breaths	12 (27.3)	0	0	2 (4.6)	4 (9.1)	26 (59.1)

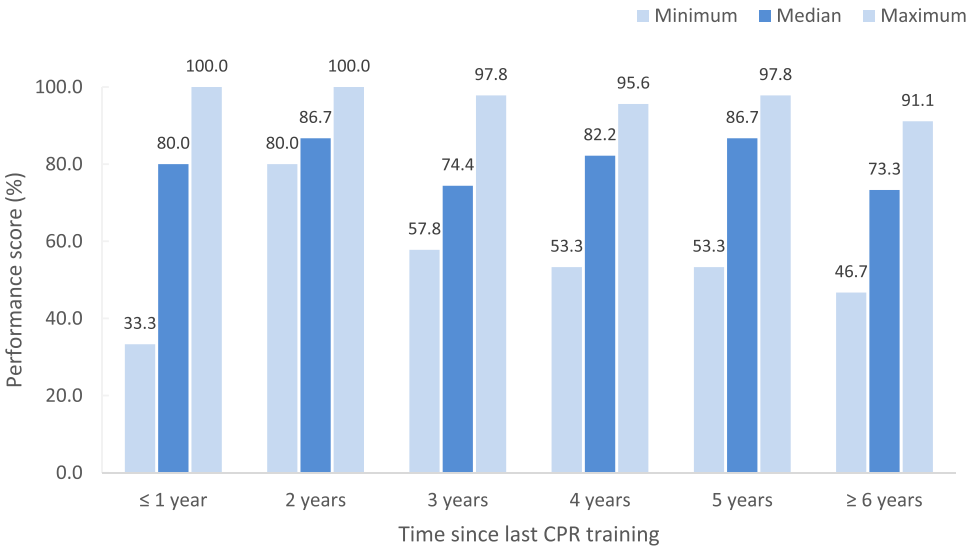

Fig. 1. Correlation of time elapsed since last CPR course and median total percentage scores.

or more for knowledge of CPR as tested by an anonymous questionnaire [7]. Regarding confidence in performing CPR, registrars had the highest percentage of feeling confident (75.4%) compared to medical officers (69.2%), intern doctors (57.7%) and specialists (53.7%). In a study in Tanzania using written and practical tests of various aspects of CPR, registrars had higher scores than specialists [8].

One of the critical characteristics of high-quality CPR is chest compressions. The registrars in this study showed correct hand placement (88.6%) and good compression depth (93.2%). On an average adult, chest compression depths of ≥ six centimetres should be avoided since it can lead to injuries or additional complications. Another general mistake made by rescuers is not compressing the patient's chest deep enough, which could lead to death since the created blood flow may be too low [1].

Only a quarter of the registrars achieved the correct compression rate in all five cycles. Rescuer fatigue may lead to an inadequate chest compression rate [9]. It is important that interruptions are minimised, and an adequate rate of chest compressions is achieved. However, rescuers should avoid an excessive compression rate (≥ 140 per minute) with an insufficient compression depth [10].

Full chest recoil was achieved consistently by only 61.4% of the registrars. This may be due to the registrar leaning on the manikin's chest while compressing, resulting in adequate depth but diminished recoil [1]. An incorrect compression rate may also have contributed to the diminished recoil. Rescuers should refrain from leaning on the patient's chest between chest compressions to permit full chest wall recoil. Inadequate recoil reduces the return of venous blood and increases intrathoracic pressure, which could lead to a fatal outcome [1].

The majority of the registrars (93.2%) achieved the correct ventilation rate. Adequate ventilation is needed to ensure visible chest rise per breath. However, caution should be exercised to avoid excessive ventilation: if the rescuer gives breaths too quickly or with too much force, air is likely to enter the stomach rather than the lungs, which can cause gastric inflation. Gastric inflation can result in vomiting, aspiration, or pneumonia [1]. Even though the registrars achieved the required ventilation rate, the targeted compression-to-ventilation ratio was only reached by 59.1% of the registrars. Almost a third of the registrars (27.3%) were not able to achieve the correct ratio in any of the five cycles.

Obtaining an open airway proved problematic, as only 63.6% of the registrars performed this step correctly. This may be due to the participants insufficiently performing the head-tilt, chin-lift manoeuvre. Most registrars (77.3%) demonstrated the E-C clamp technique correctly. Chest rise was absent/incomplete in several evaluations. This may be due to inadequate opening of the airway as well as an incorrect E-C clamp technique, leading to a decrease in ventilation, lung inflation and insufficient chest rise.

CPR skills are essential worldwide and in every setting [11]. CPR instruction is often led by an experienced health professional or a specially trained instructor. A study in Botswana tested the impact of novel training techniques on the CPR skills of hospital providers. Different instructor-student ratios, instructor-led or self-directed learning and manikin feedback switched on or off were investigated to provide guidance for resource-limited settings. The researchers concluded that the number of suitably trained instructor staff in such settings might be the limiting factor, and the use of feedback manikins may be cost-effective [5]. An experimental study at the University of the Free State found that final-year undergraduate medical students who received CPR training on conventional manikins scored comparably to students trained on electronic-feedback manikins, indicating that conventional manikins can be used effectively for training, especially in resource-limited settings. [12].

The Botswana study found that adult CPR skills were retained at 3 months post-training but decreased by 6 months [5]. Therefore, CPR refresher courses are encouraged amongst health professionals to improve memory retention of theoretical knowledge and practical skills. A scoping review regarding paediatric CPR concluded that skills retention would be improved by brief (less than an hour) and frequent (monthly or more frequent) retraining [13]. In our study, however, no correlation was found between the time elapsed since a registrar's last CPR training and their current total scores. Other factors, such as the frequency of performing resuscitations or past exposure, may play a role. In a study in North Kerala investigating the association between qualification level, years of experience, previous BLS/ACLS and employment type (private versus government) and level of CPR knowledge, only years of experience was found to be of statistical significance with knowledge being the highest in the group with less than 5 years experience [14]. Regular debriefing after resuscitation performed during clinical practise may improve an individual's CPR skills and identify any areas for improvement.

Study limitations

Due to poor intra-departmental representation in the majority of the evaluated departments, no intra- or inter-department analyses were con-

ducted. The small study sample limited the ability to make general deductions about the study population in broad. The small sample was due to the voluntary nature of participation as well as the full schedules of registrars. Registrars who chose to participate may have been those with more CPR experience.

The study focused on basic components and excluded the usage of an automatic external defibrillator (AED), although early defibrillation is the most important factor in managing early cardiac arrest. This exclusion was based on the absence of available equipment and the additional time needed for AED use. Due to logistical obstacles and conflicting schedules, there was a deviation from the original protocol procedure, which stipulated that only one evaluation session would be held per department. This alteration could have skewed the data due to inter-registrar communication. An attempt to avoid this was made by including a non-disclosure condition in the consent form.

Additionally, the rushed execution of CPR by registrars due to time constraints, as well as the fact that the evaluation scenario was a pseudo-emergency, might be responsible for skewed data. The researchers were students evaluating qualified medical professionals; this may have influenced the data due to registrars perceiving the study as trivial.

Conclusion

The study showed that registrars are not consistently performing high-quality CPR. The compression depth was predominantly adequate, but the compression rate was mostly incorrect, and full chest recoil during compressions was found to be insufficient. Difficulties in visible chest rise with ventilation and incorrect compression-to-ventilation ratio were identified. The results of this study highlight the need for regular practical CPR skills training for registrars, including regular fire drills.

The force used during resuscitation, as well as the duration of resuscitation, increase the risk of injury to the patient [15]. The risk of these injuries increases when poor quality CPR is executed, which can lead to, amongst others, legal implications for healthcare professionals [16].

Recommendations

It is recommended that annual CPR training of registrars becomes mandatory to enhance knowledge and practical skills memory retention, thus improving CPR execution. It is also recommended that future studies focus on the reasons for inefficient compression rate and other components regarding compression depth and chest recoil during CPR. The current study can be repeated with a larger sample size to compare different departments.

Authors' contributions

Authors contributed as follows to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: BH contributed 16%; CJvR 16%; AM 16%; PGM 16%; ETM 16%; JPC 8%; GJ 6%; and WJS 6%. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

The authors declare no conflict of interest.

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Dissemination of results

The results of the study were presented to undergraduate medical students during formal class sessions. The results of this study will be shared with the resuscitation team heads of the training institutions of the academic training complex in Bloemfontein.

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