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MANIKIN AND SIMULATION STUDY

The effect on quality of chest compressions and exhaustion of a compression–ventilation ratio of 30:2 versus 15:2 during cardiopulmonary resuscitation—A randomised trial[☆]

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Received 6 September 2006; received in revised form 24 November 2006; accepted 8 December 2006

KEYWORDS

Chest compression;
Cardiopulmonary
resuscitation;
Ratio;
Exhaustion

Summary

Background: Recent cardio pulmonary resuscitation (CPR) guidelines changed the compression:ventilation ratio in 30:2.

Objective: To compare the quality of chest compressions and exhaustion using the ratio 30:2 versus 15:2.

Methods: A prospective, randomised crossover design was used. Subjects were recruited from the H.-Hart hospital personnel and the University College Katho for nurses and bio-engineering. Each participant performed 5 min of CPR using either the ratio 30:2 or 15:2, then after a 15 min rest switched to the other ratio. The data were collected using a questionnaire and an adult resuscitation manikin. The outcomes included exhaustion as measured by a visual analogue scale (VAS) score, depth of chest compressions, rates of chest compressions, total number of chest compressions, number of correct chest compressions and incomplete release. Data were compared using the Wilcoxon Signed Ranks Test. The results are presented as medians and interquartile ranges (IQR).

Results: One hundred and thirty subjects completed the study. The exhaustion-score using the VAS was 5.9 (IQR 2.25) for the ratio 30:2 and 4.5 (IQR 2.88) for the ratio 15:2 ($P < 0.001$). The compression depth was 40.5 mm (IQR 15.75) for 30:2 and 41 mm (IQR 15.5) for 15:2 ($P = 0.5$).

The compression rate was 118 beats/min (IQR 29) for 30:2 and 115 beats/min (IQR 32) for 15:2 ($P = 0.02$). The total number of compressions/5 min was 347

[☆] A Spanish translated version of the summary of this article appears as Appendix in the final online version at [10.1016/j.resuscitation.2006.12.004](https://doi.org/10.1016/j.resuscitation.2006.12.004).

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(IQR 79) for 30:2 and 244 compressions/5 min (IQR 72.5) for 15:2 ($P < 0.001$). The number of correct compression/5 min was 61.5 (IQR 211.75) for 30:2 and 55.5 (IQR 142.75) for 15:2 ($P = 0.001$).

The relative risk (RR) of incomplete release in 30:2 versus 15:2 was 1.087 (95% CI = 0.633–1.867).

Conclusions: Although the 30:2 ratio is rated to be more exhausting, the 30:2 technique delivers more chest compressions and the quality of chest compressions remains unchanged.

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Introduction

For an optimal chance of success of defibrillation and outcomes, victims of cardiac arrest need immediate and adequate cardiopulmonary resuscitation (CPR) to provide a small, but critical, blood flow to the brain and heart.^{1–5} The CPR algorithms have recently been updated (guidelines 2005).⁶ These guidelines emphasise the importance of chest compressions and changed the compression:ventilation ratio to 30:2 for adult CPR.⁷ The 30:2 ratio is designed to simplify teaching, promote skill retention, increase the number of compressions given and decrease interruption to compressions.⁶

Feedback by participants of CPR courses is that the new technique (30:2) is simpler to recall but also more exhausting to perform. For adequate CPR the sternum must be compressed 4–5 cm at a rate of about 100 min⁻¹.^{2,3,8} When there is no second rescuer present, early exhaustion of the lone rescuer could compromise the outcome of the victim.^{9,10}

The objective of this study is to assess whether there is a significant difference in exhaustion and the quality of chest compressions in the ratio 30:2 versus 15:2 performed by lay and professional rescuers during the first 5 min of CPR.

Methods

The study had a prospective, randomised, crossover design and was approved by the board of the H.-Hart Hospital Roeselare, Belgium and the University College Katho for nurses and bio-engineering Roeselare, Belgium. Because there were no risks, we did not consult an ethics committee.

Subjects

The subjects were volunteers recruited from the hospital personnel and students of the university college in order to get an adequate mix of professional healthcare and lay rescuers. Participants

with cardiopulmonary diseases or severe arthritis, back pain or any (chronic) disease with physical limitations were excluded.

Setup

The same adult CPR manikin (Ambu[®]Man with Ambu[®]CPR softwarekit version 2.3) was used to collect the data. The manikin was used in the setting 'max' during the whole study.

The person who collected the data was a professional CPR instructor. The subjects and the person who collected the data were blinded from the study objective. Therefore some mock questions were added to the questionnaire.

Conduct of the study

Each participant was randomised to perform 5 min of CPR using either the ratio 30:2 or 15:2, then after a 15 min rest switched to the other ratio. Group A started CPR using the ratio 30:2 and group B started CPR with the ratio 15:2. Randomisation was done using an Internet-based random-number generator (<http://randomization.com>). According to the randomisation the subject took a place behind laptop A (30:2) or laptop B (15:2). The laptop showed a video with instructions how to participate in the study. The video also gave instructions on the allocated technique.

For both ratios the subjects were instructed to continue with the chest compressions even if the two mouth-to-mouth rescue breaths did not succeed immediately.

The subjects were blinded from the duration of performing CPR and from the monitoring devices. The person who collected the data did not intervene except to encourage the subject to continue if he or she doubted that their performance was adequate. The software registration started always at the beginning of the first chest compression (30:2) or the first ventilation (15:2) and not at the first step in the algorithm (assessments). At the end of each performance, participants were asked how

exhausting they found the 5 min CPR using a visual analogue scale (VAS) from 0 (not exhausting at all) to 10 (most exhausting imaginable). The subjects were blinded from the score. For the second ratio the subjects took place behind the other laptop to be instructed on the other technique. At the end of both sessions, subjects were asked which technique they found the most exhausting A (30:2) or B (15:2).

Outcomes

The primary outcomes were the VAS score on exhaustion and depth of chest compressions (in mm). Other outcome variables included rates of chest compressions (in beats/min), total number of chest compressions, number of correct chest compressions, and incomplete release.

Compression rate was defined as the average speed of the 30 or 15 compressions and not the number of compressions in 1 min. Correct chest compression was defined as delivery of chest compressions between 40 and 50 mm. Incomplete release was counted and registered each time the subject kept pressure on the manikin during the

relaxation period of the chest compression, as measured by the manikin. In the analysis the data relating to incomplete release were divided into incomplete release present or not present.

Data analyses

Sample size estimates suggested that 47 subjects would be needed to achieve 80% power to detect a 25% difference in the percentage of correctly performed chest compressions ($\alpha = 5\%$).¹¹ The intention however was to over sample to allow subgroup analysis.

Analyses were conducted using SPSS version 12.0.1.

Given the paired nature of these data and the fact that the data were not normally distributed, the Wilcoxon Signed Ranks Test was used to determine whether there was any difference in the outcomes generated. Continuous variables are summarised as medians and (interquartile) ranges. Dichotomous variables are presented as proportions.

Intention to treat protocol was used.

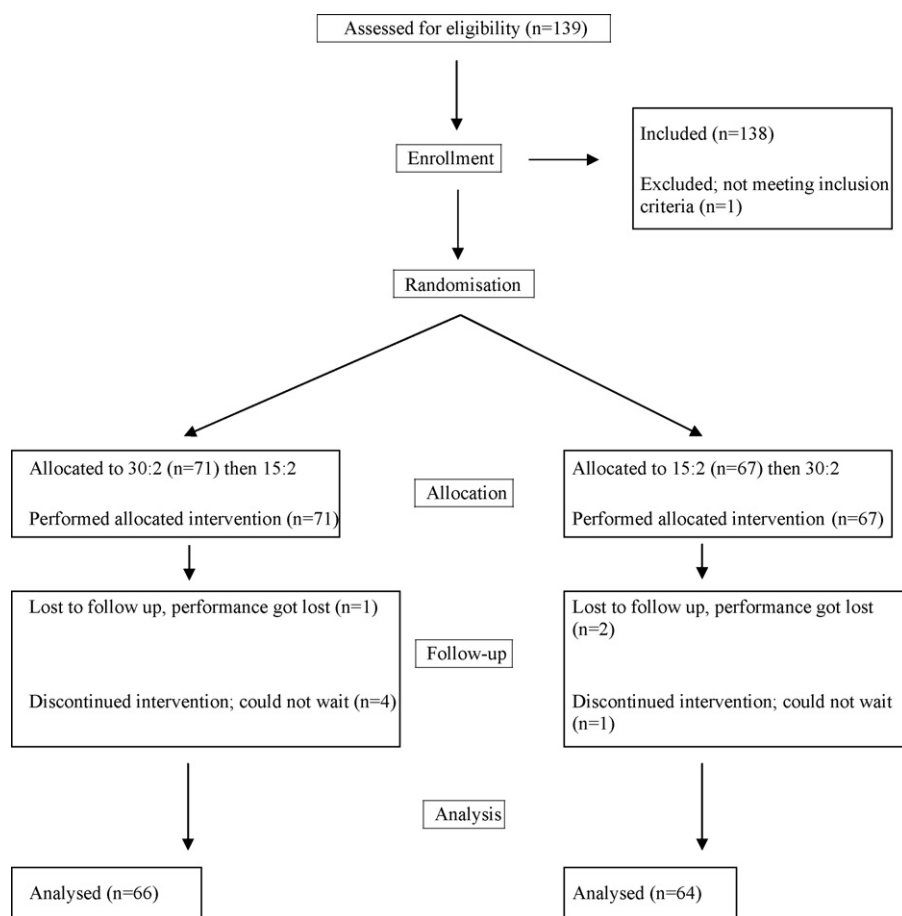


Figure 1 Randomisation.

Results

One hundred and thirty-nine subjects filled out the registration form, 138 subjects participated in the study (Figure 1). One subject was excluded because of problems with one elbow. Subject demographics are shown in Table 1. There were 56 (40.6%) lay participants (no CPR experience) and 82 (59.4%) professional participants (CPR experience). Seventy-one subjects (51.4%) started with the 30:2 ratio and 67 subjects (48.6%) started with the 15:2 ratio. One hundred and thirty subjects completed the protocol. One subject was paged after the first

demonstration and did not return: four subjects could not wait until the 15 min passed to do the second performance of 5 min CPR. From three subjects the data of one of the performances got lost accidentally.

Results are summarised in Table 2.

The difference between the exhaustion-score using the VAS for the ratio 30:2 (5.9-IQR 2.25) versus ratio 15:2 (4.5-IQR 2.88) was statistically significant ($P < 0.001$). This was confirmed by the question asking which technique is more exhausting. The response showed that the 30:2 ratio was more exhausting for 85 subjects (61.6%), and the

Table 1 Subject demographics

Total numbers of subjects	138	
Age	37	18–71
Sex		
Female	82	59.4%
Male	56	41.6%
Height	172	152–194
Weight	67	48–105
Role		
Support facilities	3	2.2%
Nurse aid	4	2.9%
Administration	8	5.8%
Student	16	11.6%
Paramedic	14	10.1%
Nurse	43	31.2%
Nurse ER, ICU, CCU, OR	22	15.9%
Medical doctor	14	10.1%
Missing data	14	10.1%
Sports activity		
Never	14	10.1%
Less than once a year	2	1.4%
Once a year	6	4.3%
More than once a year, less than once a month	12	8.7%
Once a month	9	6.5%
More than once a month, less than once a week	23	16.7%
Once a week	26	18.8%
More than once a week, less than once a day	41	29.7%
Once a day	4	2.9%
More than once a day	1	0.7%
Missing data	0	0%
CPR experience		
Never	56	40.6%
Less than once a year	27	19.6%
Once a year	18	13%
More than once a year, less than once a month	23	16.7%
Once a month	2	1.4%
More than once a month, less than once a week	9	6.5%
Once a week	0	0%
More than once a week, less than once a day	3	2.2%
Once a day	0	0%
More than once a day	0	0%
Missing data	0	0%

	30:2	15:2	<i>P</i>
Exhaustion-score using the VAS	5.9 (IQR 2.25)	4.5 (IQR 2.88)	<0.001
The more exhausting technique	30:2 85 (61.6%)	15:2 39 (28.3%)	None/missing 14 (10.1%)
Compression depth (mm)	40.5 (IQR 15.75)	41 (IQR 15.5)	0.5
Compression rate (beats/min)	118 (IQR 29)	115 (IQR 32)	0.02
Total number of compressions/5 min	347 (IQR 79)	244 (IQR 72.5)	<0.001
Total number of correct compression/5 min	61.5 (IQR 211.75)	55.5 (IQR 142.75)	0.001

15:2 was more exhausting for 39 subjects (28.3%). It was the same for nine subjects (6.5%), and for five subjects had no idea or the data was missing (3.6%).

The compression depth was 40.5 mm (IQR 15.75) for 30:2 and 41 mm (IQR 15.5) for 15:2 ($P=0.5$).

The compression rate was 118 beats/min (IQR 29) for 30:2 and 115 beats/min (IQR 32) for 15:2 ($P=0.02$).

The total number of compressions/5 min was 347 (IQR 79) for 30:2 and 244 compressions/5 min (IQR 72.5) for 15:2 ($P<0.001$).

The number of correct compression/5 min was 61.5 (IQR 211.75) for 30:2 and 55.5 (IQR 142.75) for 15:2 ($P=0.001$).

There was no significant difference in incomplete release for 30:2 versus 15:2 (RR = 1.087, 95% CI = 0.633–1.867).

We also performed a subgroup analysis for randomisation. Each first performance A (starting 30:2, $N_A=70$) or B (starting 15:2, $N_B=65$) was compared. The compression depth for the subgroup A was 40.5 mm (IQR 15.5) and 44 mm (IQR 16) for B ($P=0.58$).

Discussion

We investigated the feeling of exhaustion during the 30:2 versus the 15:2 ventilation–compression ratio and we compared this with the quality of chest compressions in both techniques. This study demonstrates that although people find the 30:2 ratio to be more exhausting, no evidence can be found that the 30:2 technique is more difficult to perform or to maintain over 5 min.

Since we used a VAS score to measure exhaustion, we cannot determine if there was a difference in physical exhaustion of the subjects as this would require other outcome measures such as the heart rate of the participants.

In both ratios the compression depth was in the range of the recommended values (40–50 mm)^{2,3} and no difference was found.

It must be noted that in this study the average depth of compression over 5 min was compared. It is thus theoretically possible to find the same outcome when a subject starts with very deep compressions and ends with very superficial compressions in one technique compared to a steady

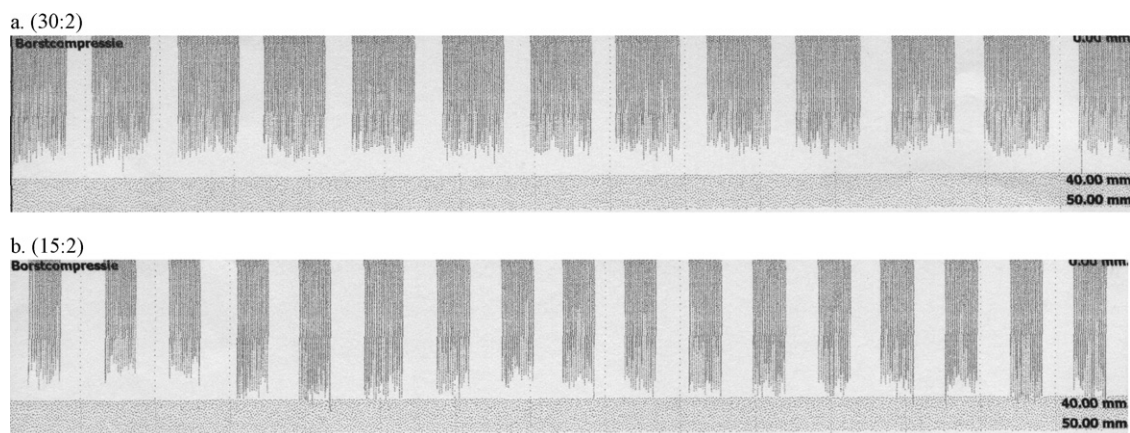


Figure 2 Graphs showing the quality of chest compression during 5 min.

adequate compression for 5 min in the other technique. However a cursory inspection of the graphs did not appear to support this possibility (Figure 2).

In both ratios the compression rate was above the recommended rate (100 min^{-1}).⁸ In the 30:2 technique the compression rate was significantly higher. Considering all data it is our opinion this cannot be explained as a sign of exhaustion. One would expect a low rate rather than a high rate to be a sign of exhaustion. A higher rate could also reflect a compensation for a decreased compression depth. However this was not the case in this study. It remains to be shown whether this difference in rate is clinically significant in preload and cardiac output. It must be remembered that this study only examines the outcomes measured in a manikin. There are no outcomes in this study in terms of the physiology variables during resuscitation, as for example arterial, coronary and cerebral perfusion flow generated by the two techniques. Also it remains to be shown whether this difference in compression rates appears in real situations (Hawthorne effect).

An other important finding is that the 30:2 ratio resulted in a greater number of (correct) chest compressions performed during 5 min, one of the reasons why the ratio was changed to 30:2.⁶

The incidence of incomplete release in 30:2 showed no reason to suppose that this technique was less adequate than the 15:2 technique.

One could question if the 15 min pause was long enough. Therefore a subgroup analysis, using only the first performed technique (randomisation A versus B), was done and the same effects occurred.

It may be worthwhile to examine the effects of a longer period of chest compression (>5 min). It can be considered as normal that exhaustion will occur after 5 min one-person CPR.

Finally the data also showed many poor compressions in both techniques which emphasises the need for frequent training. The effect of more chest compressions delivered with the 30:2 ratio could be more impressive if rescuers performed more adequate chest compressions in relation to the total of delivered compressions.

Training could also be a solution for the high compression rates in both techniques, and the rate must be emphasised during training.

Conclusions

Although the 30:2 ratio is rated to be more exhausting, the 30:2 technique delivers more chest

compressions and the quality of chest compressions remains unchanged.

Conflict of interest statement

None.

Acknowledgements

We would like to thank Mr. Rosseel dir. nursing H.-Hart Hospital Roeselare and Mr. Cools Katho Roeselare for their cooperation and their facilities which could be used during the data collection. We thank Mr. De Vries for the use of his research material. Finally we also thank all the volunteers who participated in this study.

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