Elsevier Editorial System(tm) for Resuscitation
Manuscript Draft

Manuscript Number: RESUS-D-19-00299R1

Title: The impact of resuscitation guideline terminology on quality of dispatcher-assisted cardiopulmonary resuscitation: a randomised controlled manikin study.

Article Type: Original paper

Section/Category: Simulation and education

Keywords: cardiac arrest; terminology; dispatcher-assisted cardiopulmonary resuscitation; guidelines; randomised controlled trial

Corresponding Author: Dr. Keith Couper,

Corresponding Author's Institution: Heart of England NHS Foundation Trust

First Author: Samuel P Trethewey

Order of Authors: Samuel P Trethewey; Hrushikesh Vyas; Sarah Evans; Michelle Hall; Teresa Melody; Gavin D Perkins; Keith Couper

Abstract: Background:
Cardiopulmonary resuscitation (CPR) guidelines vary in the terminology used to describe target chest compression depth, which may impact CPR quality. We investigated the impact of using different chest compression depth instruction terminologies on CPR quality.

Methods:
We conducted a parallel group, three-arm, randomised controlled manikin trial in which individuals without recent CPR training were instructed to deliver compression-only CPR for 2-minutes based on a standardised dispatcher-assisted CPR script. Participants were randomised in a 1:1:1 ratio to receive CPR delivery instructions that instructed them to deliver chest compressions based on the following terminologies: 'press at least 5 cm', 'press approximately 5 cm' or 'press hard and fast.' The primary outcome was compression depth, measured in millimetres.

Results:
Between October 2017 and June 2018, 330 participants were randomised to 'at least 5 cm' (n=109), 'approximately 5 cm' (n=110) and 'hard and fast' (n=111), in which mean chest compression depth was 40.9 mm (SD 13.8), 35.4 mm (SD 14.1), and 46.8 mm (SD 15.0) respectively. Mean difference in chest compression depth between 'at least 5 cm' and 'approximately 5 cm' was 5.45 (95% confidence interval (95%CI) 0.78 to 10.12), between 'hard and fast' and 'approximately 5 cm' was 11.32 (95% CI 6.65 to 15.99), and between 'hard and fast' and 'at least 5 cm' was 5.87 (95% CI 1.21 to 10.53). Chest compression rate and count were both highest in the 'hard and fast' group.

Conclusions:
The use of 'hard and fast' terminology was superior to both 'at least 5 cm' and 'approximately 5 cm' terminologies.

Trial registration: ISRCTN15128211.

Title:

The impact of resuscitation guideline terminology on quality of dispatcher-assisted cardiopulmonary resuscitation: a randomised controlled manikin study.

Authors:

Samuel P. Trethewey[1], Hrushikesh Vyas[1], Sarah Evans[1], Michelle Hall,[1] Teresa Melody[1], Gavin D. Perkins[1,2], Keith Couper[1,2]

Drs Trethewey and Vyas are joint first authors

Institutions:

1. Critical Care Unit, Birmingham Heartlands Hospital, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK.

2. Warwick Clinical Trials Unit, Warwick Medical School, University of Warwick, Coventry, UK.

Corresponding author details:

Dr Keith Couper

Telephone: +44(0)121 4242966

E-mail: k.couper@warwick.ac.uk

Address: Critical Care Unit, Birmingham Heartlands Hospital, University Hospitals Birmingham NHS Foundation Trust, Bordesley Green East, Birmingham, B9 5SS.

Word count:

Abstract 257

Main text- 2398

Keywords: cardiac arrest; terminology; dispatcher-assisted cardiopulmonary resuscitation; guidelines; randomised controlled trial

Abstract

Background:

Cardiopulmonary resuscitation (CPR) guidelines vary in the terminology used to describe target chest compression depth, which may impact CPR quality. We investigated the impact of using different chest compression depth instruction terminologies on CPR quality.

Methods:

We conducted a parallel group, three-arm, randomised controlled manikin trial in which individuals without recent CPR training were instructed to deliver compression-only CPR for 2-minutes based on a standardised dispatcher-assisted CPR script. Participants were randomised in a 1:1:1 ratio to receive CPR delivery instructions that instructed them to deliver chest compressions based on the following terminologies: 'press at least 5 cm', 'press approximately 5 cm' or 'press hard and fast.' The primary outcome was compression depth, measured in millimetres.

Results:

Between October 2017 and June 2018, 330 participants were randomised to 'at least 5 cm' (n=109), 'approximately 5 cm' (n=110) and 'hard and fast' (n=111), in which mean chest compression depth was 40.9 mm (SD 13.8), 35.4 mm (SD 14.1), and 46.8 mm (SD 15.0) respectively. Mean difference in chest compression depth between 'at least 5 cm' and 'approximately 5 cm' was 5.45 (95% confidence interval (95%CI) 0.78 to 10.12), between 'hard and fast' and 'approximately 5 cm' was 11.32 (95% CI 6.65 to 15.99), and between 'hard and fast' and 'at least 5 cm' was 5.87 (95% CI 1.21 to 10.53). Chest compression rate and count were both highest in the 'hard and fast' group.

Conclusions:

The use of 'hard and fast' terminology was superior to both 'at least 5 cm' and 'approximately 5 cm' terminologies.

Trial registration: ISRCTN15128211.

Introduction:

International survival following adult out-of-hospital cardiac arrest (OHCA) is poor with only approximately 10% of patients surviving to hospital discharge.[1, 2] Following cardiac arrest, immediate treatment with high-quality cardiopulmonary resuscitation (CPR) is essential to increase the likelihood of survival.[3] A key component of high-quality CPR is chest compression depth.[4-6]

In 2015, the International Liaison Committee on Resuscitation, based on its evaluation of scientific literature, made a treatment recommendation that chest compressions should be delivered at a depth of “approximately 5 cm.”[7] The translation of this treatment recommendation in to clinical guidelines has produced variability in guideline language, both between and within guidelines. For example, Resuscitation Council of Asia guidelines recommend a depth of approximately 5 cm, whilst American Heart Association guidelines recommend a depth of at least 5 cm.[8, 9] Within the European Resuscitation Council guidelines, the main text recommends a depth of at least 5 cm, whilst the step-by-step basic life support sequence of action figure instructs rescuers to “press down on the sternum approximately 5 cm.”[10]

Previous studies have highlighted the potential impact of CPR instruction terminology on CPR delivery.[11-17] Driven by these data and current variability in guideline terminology, we designed a randomised controlled manikin trial to compare the effect of these terminologies when used in the context of dispatcher-assisted CPR delivered to an adult. We incorporated a third arm of ‘hard and fast’ based on the terminology’s use in high-profile media campaigns by the American Heart Association and the British Heart Foundation.[18, 19]

Methods:

We conducted a three-armed, parallel group, single-centre, randomised controlled manikin trial to evaluate the effect of CPR delivery instruction terminology on CPR quality delivered by people without recent practical CPR training.

The protocol was approved by the West Midlands Edgbaston Research Ethics Committee and Health Research Authority. The study was funded by Resuscitation Council (UK). The trial sponsor was Heart of England NHS Foundation Trust. The trial protocol was registered with the ISRCTN registry (ISRCTN15128211). The trial was conducted in conformance with the principles of the Declaration of Helsinki and Medical Research Council Good Clinical Practice guidelines.

Participants

We included adults (≥18 years) that had provided written informed consent to participate and who did not meet any exclusion criteria. Exclusion criteria were: physical disability that prevented delivery of CPR for 2 minutes while kneeling on the floor, previous study participation, receipt of practical CPR training in the preceding two years, non-English speaking, and hospital employees working in a clinical role.

Participants were informed that the purpose of the study was to determine the optimal method to direct bystanders how to deliver CPR over the telephone. Participants were not explicitly informed as to the primary outcome or how instructions differed between groups. As a thank you for supporting the study, participants were offered the opportunity to attend a CPR course following the completion of recruitment. We recruited participants at hospital sites which comprised Heart of England NHS Foundation Trust. Recruitment strategies focussed on non-clinical staff members, outpatients, and hospital visitors.

Randomisation and interventions

Following assessment of eligibility and provision of written informed consent, participants were sequentially randomised in a 1:1:1 ratio using an online randomisation system (sealedenvelope.com, London, UK). The allocation sequence was created through the randomisation system website, using random block sizes divisible by three. Researchers were blinded to the allocation until the point of randomisation.

Following randomisation, participants were informed that a 70-year old male (‘the patient’) had collapsed at a local community centre and that they had telephoned the Emergency Medical Services, who had dispatched an ambulance. The participant was then informed that the patient had been confirmed as having a cardiac arrest and that the telephone dispatcher would instruct them on how to deliver CPR to the manikin for a period of two minutes.

An audio recording was then played. The audio recording script was based on that used by emergency medical system dispatchers in the UK. The only difference between arms was the terminology used to describe the target chest compression depth, namely ‘press down on the chest hard and fast’, ‘press down on the chest at least 5 cm or 2 inches’ and ‘press down on the chest approximately 5 cm or 2 inches.’ In addition, participants in the ‘hard and fast’ group did not receive an indication on the recording as to the correct rate. At the end of the scenario, participants were given very brief feedback on the quality of CPR provided.

Outcome measures

The primary trial outcome measure was mean chest compression depth (mm) during the scenario. Secondary outcomes were: chest compression rate (min^{-1}), chest compression count, % of chest compressions in target rate range (100-120 compressions per minute), % of chest compressions in target depth range (≥50 mm), and % delivery of good quality CPR over two-minute study period (defined as percentage compressions with complete release and of adequate depth and rate).

Equipment and outcome assessment

The same items of equipment were used in all scenarios. We used a ‘Little Anne CPR manikin’ (Laerdal Medical, Stavanger, Norway). Quality of CPR was measured using a ‘CPRmeter’ (Laerdal Medical, Stavanger, Norway) device placed on the manikin’s chest during the intervention. The device display was occluded during the assessment, so that the study participant received no real-time feedback on performance.

CPR quality data were downloaded to manufacturer software (Q-CPR Review 3, Laerdal Medical, Stavanger, Norway). A researcher who was blinded to treatment allocation reviewed the data to identify the first chest compression and the ensuing two-minute period. Based on this input, the software automatically calculated CPR metrics.

Statistical analysis and sample size

Our planned sample size was 330 participants. Based on 90% power and a significance level of 0.05, we identified that we would need 102 participants in each study arm to reliably detect a clinically important 5 mm difference in chest compression depth between groups.[4-6] In calculating the sample size, we made a conservative estimate of the standard deviation (SD=11), based on the work by Mirza et al.[11] An additional 24 participants were included to account for drop-outs and data loss.

Continuous data were assessed for normality. Normally distributed continuous data are described as mean and standard deviation (SD); non-normally distributed continuous data are described as median and interquartile range. Categorical data are described as count and percentage. Outcome data are all continuous data-points. We analysed outcome data in two ways. Firstly, we compared all three groups using an ANOVA test or Kruskal-Wallis test, as appropriate. Secondly, where data were normally distributed, we examined differences using the Tukey HSD test and report the mean difference and 95% confidence interval (CI). All analyses were undertaken on an intention-to-treat basis. We did not pre-specify any adjusted analyses. All tests are two-tailed with a p-value cut-off for significance of 0.05. We analysed data using the SPSS statistical program (V23.0, IBM Corporation, Armonk, New York, United States).

Results:

Between October 2017 and June 2018, we screened 573 individuals of which 330 were randomised in the trial. Main reasons for exclusion included declination (n=131), receipt of CPR training in preceding two years (n=50), and disability preventing CPR delivery for two-minutes (n=30). A study CONSORT flow diagram is shown as figure one.

Of the 330 randomised participants, 109 were randomised to 'at least 5 cm', 110 were randomised to 'approximately 5 cm' and 111 were randomised to 'hard and fast.' Demographic data were available for all participants. We collected outcome data for 314 (95.2%) participants, thereby exceeding our required sample size. Missingness of outcome data was comparable across groups and was attributable either to human error or technical problems in all cases. There were three randomisation errors: two participants were randomised out of order and one participant received the incorrect allocation. In accordance with intention-to-treat principles, these participants were analysed as per the original allocation sequence. In participants where outcome data were available, 308 (98.1%) participants delivered CPR for the expected 2-minute period.

The mean age of participants was 44.4 (SD 14.8) years. A minority were male (n=94, 28.5%), had previously received practical CPR training (n=125, 37.9%) and had delivered CPR in real-life (n=22, 6.7%). The mean height and weight of participants was 166.4 cm (SD 9.8) and 71.8 kg (SD 16.1) respectively. Participant characteristics are summarised in table one.

Mean chest compression depth in the 'at least 5 cm', 'approximately 5 cm' and 'hard and fast' groups was 40.9 mm (SD 13.8), 35.4 mm (SD 14.1) and 46.8 mm (SD 15.0) respectively, summarised in Table 2. Mean difference in chest compression depth between 'at least 5 cm' and 'approximately 5 cm' was 5.45 (95% CI 0.78 to 10.12), between 'hard and fast' and 'approximately 5 cm' was 11.32 (95% CI 6.65 to 15.99) and between 'hard and fast' and 'at least 5 cm' was 5.87 (95% CI 1.21 to 10.53).

Mean chest compression rate was highest in the 'hard and fast' group (98.9 min^{-1}, SD 31.8), compared with 'at least 5 cm' (83.7 min^{-1}, SD 29.4) and 'approximately 5 cm' (71.2 min^{-1}, SD 33.7). Between group mean differences were 12.44 (95% CI 2.07 to 22.81) for ‘at least 5 cm’ and ‘approximately 5 cm’, 27.65 (95% CI 17.33 to 37.96) for ‘hard and fast’ and ‘approximately 5 cm’ and 15.21 (95% CI 4.86 to 25.55) for ‘hard and fast’ and ‘at least 5 cm.’ All other CPR quality metrics were also highest in the ‘hard and fast’ group.

There were three protocol deviations in which researchers mistakenly allowed participants to deliver CPR with the manikin placed on a table or chair, rather than sited on the floor. Two of these occurred in the ‘at least 5 cm’ group and one in the ‘approximately 5 cm’ group. There were four adverse events which required early termination of CPR delivery. Two participants reported shoulder pain, one reported knee pain, and one reported tiredness. Three of these events occurred in the ‘hard and fast’ group and one event in the ‘at least 5 cm’ group.

Discussion:

In this randomised controlled manikin trial of 330 participants without recent CPR training, we found that participants who were instructed to press ‘hard and fast’ delivered the highest quality chest compressions, in terms of chest compressions depth, chest compression rate and delivery of high-quality compressions. The instructions to deliver compressions to a depth of ‘approximately 5 cm’ and ‘at least 5 cm’ resulted in chest compressions that were markedly below target depth and target rate.

Our study contributes to the growing body of literature that the terminology used to instruct CPR delivery impacts on CPR quality in both untrained and trained rescuers, although data are all derived from the simulation setting.[11-17] In line with our findings, these studies typically found that simplified instructions that do not incorporate a depth measurement result in higher-quality chest compressions. However, in contrast to other studies, Deakin et al reported a decreased compression depth when rescuers were instructed to ‘push as hard as you can,’ compared with an instruction to compress to a depth of 5 cm.[17]

Terminology used by a telephone dispatcher to instruct bystander CPR delivery may be one of the few modifiable factors that influences CPR quality in OHCA where a trained bystander is not present. Recent studies show the quality of CPR delivered by bystanders is often close to guideline targets for depth and rate.[20, 21] However, such data are at high risk of selection bias as CPR quality data are only available when a public access defibrillator is used. In the UK, public access defibrillators are used in only 2.4% of OHCA.[1]

The most likely explanation for our study findings is that rescuers find simplified instructions easier to follow, particularly given that chest compression depth is challenging to reliably estimate.[22] In a recent manikin trial where healthcare professionals were randomised to deliver CPR at different target depths, an increased instructed target depth led to deeper chest compressions, but the delivered depth was consistently lower than the target depth.[12] Our study further shows that the inclusion of a qualifier, such as ‘at least’ or ‘approximately’, in a compression depth instruction does affect rescuer behaviour.

The lower chest compression rate observed in the ‘approximately 5 cm’ and ‘at least 5 cm’ arms may be partly explained by the audio instructions, which incorporated an indication of rate for these groups. In contrast, participants in the ‘hard and fast’ arm received no audio indication of rate. Interestingly, whilst the mean differed markedly across groups, the standard deviation was broadly similar. In our study, the use of pre-recorded audio instructions precluded correction of rate by the dispatcher. However, in clinical practice, this dispatcher may be able to determine chest compression rate through sounds made by the bystander, and provide corrective instructions as needed.

In our study, the observed impact on chest compression depth is potentially clinically important. Large observational studies demonstrate the association between chest compression depth and patient outcome.[4-6] In a study of 9,136 out-of-hospital cardiac arrests, Stiell et al. identified the odds ratio of pre-hospital return of spontaneous circulation as being 1.06 (95% CI 1.04 to 1.08) for each 5 mm increase in chest compression depth.[6] In our study, the point estimate for the observed mean difference for each between group difference was at least 5 mm.

The translation of resuscitation science in to clinical practice is a complex process.[23] As highlighted in this study, subtle terminology changes may have a significant impact on rescuer performance in the real-world. As such, there is a need for guideline writers and policy makers to consider carefully the impact of terminology when developing documents that inform clinical practice.

Our trial has several key limitations. Firstly, our use of a manikin model in the trial design limits the trial's generalisability to the clinical setting, as the manikin model cannot reliably replicate how rescuers react or the practical challenges present in the real-life setting.[24] Secondly, for practical reasons, recruitment took place in a hospital setting, such that our study population may not reflect the general population. Thirdly, CPR instructions were delivered in the English language and we restricted recruitment to English-speaking participants, such that the generalisability of our findings to other languages has not been determined.

Conclusions:

The findings from this study demonstrate that resuscitation terminology has an important effect on delivery of CPR by untrained bystanders in simulated OHCA. Further research is required to evaluate the role of this simplified terminology and its possible effect on CPR delivery in real-life OHCA.

Contributions: KC conceived and designed the study, participated in acquisition of data, analysis and interpretation of data, revised the article and gave final approval of the version submitted. MH, SE, TM and GDP participated in study conception and design, revised the article and gave final approval of the version submitted. SPT and HV participated in acquisition of data, analysis and interpretation of data, revised the article and gave final approval of the version submitted. SPT and HV are joint first authors.

Acknowledgements: We would like to thank the critical care research team at Birmingham Heartlands Hospital for their contribution to acquisition of data. We also thank Dr Ryan Laloo for his support in extracting outcome data.

Funding: This study was supported by a research grant awarded by Resuscitation Council (UK). KC is supported by an NIHR post-doctoral fellowship award.

Conflicts of interest: Professor Perkins is an editor of Resuscitation, co-chair of the International Liasion Committee on Resuscitation, European Resuscitation Council director of guidelines, and chair of the Resuscitation Council (UK) Community Ambulance Committee. The remaining authors have no conflicts of interest to declare.

[1] Hawkes C, Booth S, Ji C, et al. Epidemiology and outcomes from out-of-hospital cardiac arrests in England. Resuscitation. 2017;110:133-40.

[2] Benjamin EJ, Virani SS, Callaway CW, et al. Heart Disease and Stroke Statistics- 2018 Update: A Report From the American Heart Association. Circulation. 2018;137:e67-e492.

[3] Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: A graphic model. Ann Emerg Med. 1993;22:1652-8.

[4] Stiell IG, Brown SP, Christenson J, et al. What is the role of chest compression depth during out-of-hospital cardiac arrest resuscitation? Crit Care Med. 2012;40:1192-8.

[5] Vadeboncoeur T, Stolz U, Panchal A, et al. Chest compression depth and survival in out-of-hospital cardiac arrest. Resuscitation. 2014;85:182-8.

[6] Stiell IG, Brown SP, Nichol G, et al. What Is the Optimal Chest Compression Depth During Out-of-Hospital Cardiac Arrest Resuscitation of Adult Patients? Circulation. 2014;130:1962-70.

[7] Perkins GD, Travers AH, Berg RA, et al. Part 3: Adult basic life support and automated external defibrillation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation. 2015;95:e43-e69.

[8] Chung SP, Sakamoto T, Lim SH, et al. The 2015 Resuscitation Council of Asia (RCA) guidelines on adult basic life support for lay rescuers. Resuscitation. 2016;105:145-8.

[9] Kleinman ME, Brennan EE, Goldberger ZD, et al. Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality. 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015;132:S414-S35.

[10] Perkins GD, Handley AJ, Koster RW, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation. 2015;95:81-99.

[11] Mirza M, Brown TB, Saini D, et al. Instructions to "push as hard as you can" improve average chest compression depth in dispatcher-assisted Cardiopulmonary Resuscitation. Resuscitation. 2008;79:97-102.

[12] Deakin CD, Sidebottom DB, Potter R. Can rescuers accurately deliver subtle changes to chest compression depth if recommended by future guidelines? Resuscitation. 2018;124:58-62.

[13] Rodriguez SA, Sutton RM, Berg MD, et al. Simplified dispatcher instructions improve bystander chest compression quality during simulated pediatric resuscitation. Resuscitation. 2014;85:119-23.

[14] Rasmussen SE, Nebsbjerg MA, Krogh LQ, et al. A novel protocol for dispatcher assisted CPR improves CPR quality and motivation among rescuers—A randomized controlled simulation study. Resuscitation. 2017;110:74-80.

[15] Painter I, Chavez DE, Ike BR, et al. Changes to DA-CPR instructions: Can we reduce time to first compression and improve quality of bystander CPR? Resuscitation. 2014;85:1169-73.

[16] Dias JA, Brown TB, Saini D, et al. Simplified dispatch-assisted CPR instructions outperform standard protocol. Resuscitation. 2007;72:108-14.

[17] Deakin CD, Cheung S, Petley GW, Clewlow F. Assessment of the quality of cardiopulmonary resuscitation following modification of a standard telephone-directed protocol. Resuscitation. 2007;72:436-43.

[18] British Heart Foundation. Hands only CPR: Never do nothing. Available at https://www.bhf.org.uk/how-you-can-help/how-to-save-a-life/hands-only-cpr; last accessed 2nd April 2019.

[19] American Heart Association. Hands - Only CPR. 2019. Available at https://international.heart.org/en/hands-only-cpr; last accessed 2nd April 2019.

[20] Gyllenborg T, Granfeldt A, Lippert F, Riddervold IS, Folke F. Quality of bystander cardiopulmonary resuscitation during real-life out-of-hospital cardiac arrest. Resuscitation. 2017;120:63-70.

[21] Fernando SM, Vaillancourt C, Morrow S, Stiell IG. Analysis of bystander CPR quality during out-of-hospital cardiac arrest using data derived from automated external defibrillators. Resuscitation. 2018;128:138-43.

[22] van Tulder R, Laggner R, Kienbacher C, et al. The capability of professional- and lay-rescuers to estimate the chest compression-depth target: A short, randomized experiment. Resuscitation. 2015;89:137-41.

[23] Dainty KN, Brooks SC, Morrison LJ. Are the 2010 guidelines on cardiopulmonary resuscitation lost in translation? A call for increased focus on implementation science. Resuscitation. 2013;84:422-5.

[24] Ho AFW, Sim ZJ, Shahidah N, et al. Barriers to dispatcher-assisted cardiopulmonary resuscitation in Singapore. Resuscitation. 2016;105:149-55.

Figure

Figure one- Study CONSORT flow diagram

Table

Table one: demographic data

		At least 5cm (n=109)	Approx 5cm (n=110)	Hard and fast (n=111)	All cases (n=330)
Demographic variables†					
	Age- mean (SD)	43.4 (14.3)	44.5 (14.4)	45.4 (15.6)	44.4 (14.8)
	Sex-male- n(%)	37 (33.9)	24 (21.8)	33 (30.0)	94 (28.5)
	Height (cm)- mean (SD)	168.7 (10.9)	164.9 (9.4)	165.7 (8.7)	166.4 (9.8)
	Weight (kg)- mean (SD)	75.8 (17.5)	71.5 (16.1)	68.0 (13.6)	71.8 (16.1)
	Previously received CPR training- n(%)	45 (41.3)	37 (33.6)	43 (38.7)	125 (37.9)
	Previously delivered CPR- n(%)	10 (9.2)	5 (4.5)	7 (6.3)	22 (6.7)
Process variables‡					
	Delivered 2 minutes CPR, as planned- n(%)	105 (100)	101 (97.1)	102 (97.1)	308 (98.1)
	Duration of CPR outcome data- median (IQR)	2 (2, 2)	2 (2, 2)	2 (2, 2)	2 (2, 2)

†- Missingness across variables- age (1 case); sex (2 cases); height (3 cases); weight (36 cases); previously received CPR training (0 cases); previously delivered CPR (0 cases)

‡- Data available only for cases with outcome data: at least 5cm- 105 cases; approximately 5cm- 104 cases; hard and fast- 105 cases.

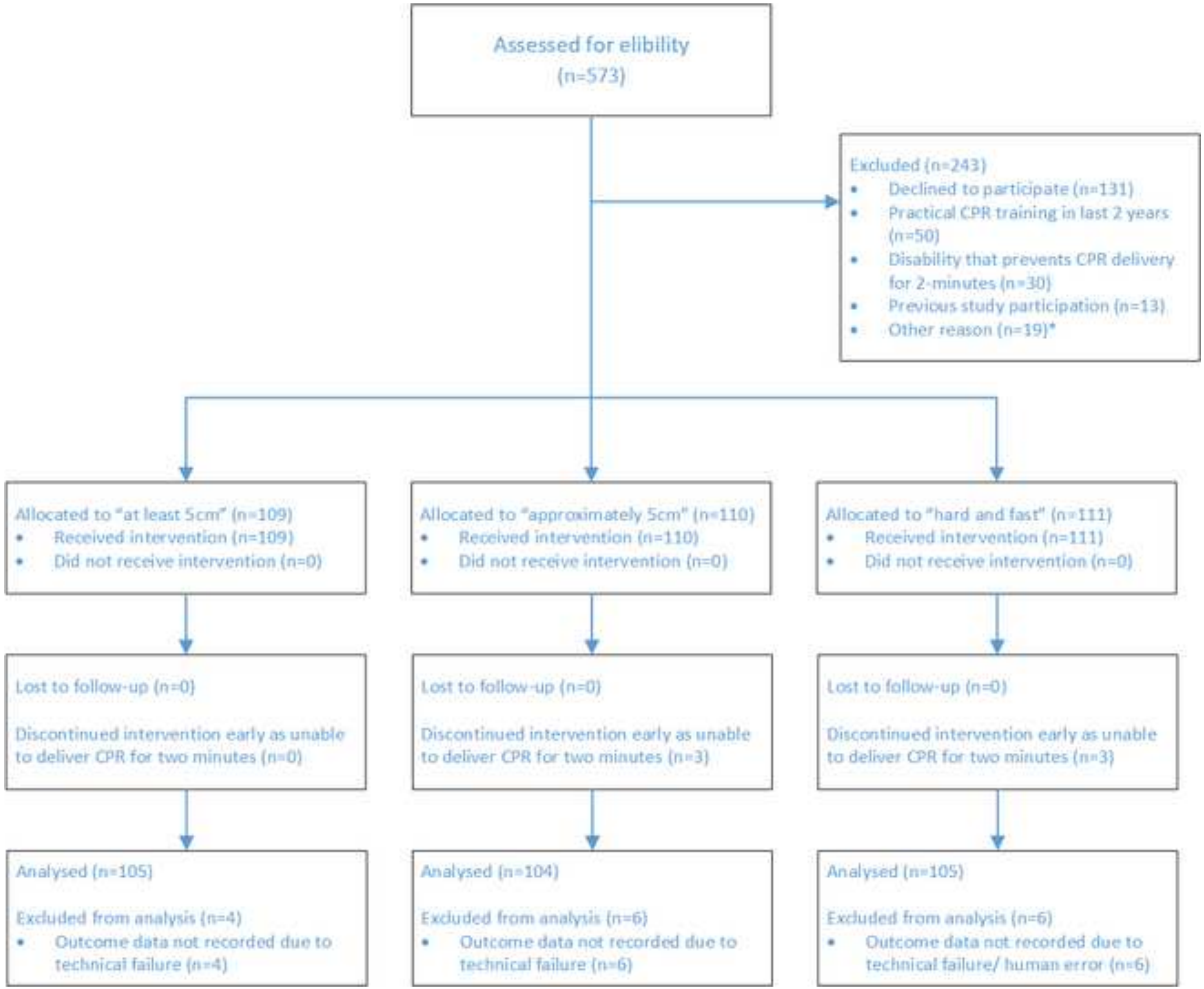
Table two: Study outcome data

	At least 5cm (n=105)	Approx 5cm (n=104)	Hard & fast (n=105)	P-value	At least v Approx.		Hard & fast v Approx.		Hard & fast v at least	
					Difference (95% CI)	p-value	Difference (95% CI)	p-value	Difference (95% CI)	p-value
Compression depth- mm- mean (SD)	40.9 (13.8)	35.4 (14.1)	46.8 (15.0)	<0.001	5.45 (0.78, 10.12)	0.017	11.32 (6.65, 15.99)	<0.001	5.87 (1.21, 10.53)	0.009
Compression rate ($/min^{-1}$)- mean (SD)†	83.7 (29.4)	71.2 (33.7)	98.9 (31.8)	<0.001	12.44 (2.07, 22.81)	0.014	27.65 (17.33, 37.96)	<0.001	15.21 (4.86, 25.55)	0.002
Compression count- mean (SD)	169.4 (69.0)	139.4 (67.6)	196.6 (64.5)	<0.001	30.05 (8.21, 51.90)	0.004	57.26 (35.42, 79.11)	<0.001	27.21 (5.41, 49.0)	0.01
% Compressions in target rate range- median (IQR)	23.0 (0.0, 52.0)	1.5 (0.0, 32.3)	4.0 (0.0, 37.5)	0.013						
% Compression in target depth range- median (IQR)	6.0 (0.0, 66.5)	0.0 (0.0, 36.3)	32.0 (1.0, 95.5)	<0.001						
% Good compressions- median (IQR)‡	5.0 (0.0, 55.0)	0.0 (0.0, 22.5)	18.0 (0.0, 85.0)	<0.001						

† - 3 cases with missing data; ‡- 2 cases with missing data

Figure one: Study CONSORT flow diagram

Click here to download high resolution image



CONSORT checklist

Click here to download Supplemental files for online publication only: CONSORT_DIRECT.doc

Conflicts of interest: Professor Perkins is an editor of Resuscitation, co-chair of the International Liasion Committee on Resuscitation, European Resuscitation Council director of guidelines, and chair of the Resuscitation Council (UK) Community Ambulance Committee. The remaining authors have no conflicts of interest to declare.