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Simulation and education

Cardiopulmonary resuscitation retention training for hospital nurses by a self-learner skill station or the traditional instructor led course: A randomised controlled trial

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Abstract

Introduction: Intrahospital cardiac arrest has a steep mortality and high-quality cardiopulmonary resuscitation (CPR) is essential for favourable outcome. Instructor led (IL) CPR training is resource demanding and instructor free, feedback providing CPR skill stations (SS) could provide a means to enable the needed frequent retraining. The main objective of this study was to test the hypothesis that there was no difference between IL and SS training.

Methods: A total of 129 hospital nurses were randomised to CPR retraining in three groups; skill station with retraining at 2 months (SS-R), skill station without retraining (SS) and instructor led training (IL). Participants were tested at baseline, 2 and 8 months. The skill station groups were combined (c-SS) for analysis at baseline and 2 months when comparing to IL.

Results: Baseline characteristics for the three groups differed significantly, however c-SS and IL groups performed equally at baseline and testing at 2 months. At 8 months the SS group performed 71% correct ventilations compared to 54% in the IL group ($p = 0.04$), but CPR quality was otherwise equal. Longitudinal analysis showed SS-R performed 3.4 mm deeper compressions at final evaluation compared to baseline ($p = 0.02$) and 2.8 mm deeper compared to 2-month test ($p = 0.02$). No effects of retraining at 2 months could be detected at final comparison of SS-R and SS groups.

Conclusion: CPR training using a skill station led to equal performance at 2 and 8 months compared to instructor led training. Feedback-providing skill stations could be a feasible tool for required frequent retraining.

Keywords: CPR Self-instruction Instructor Skill retention Technical skills Resuscitation Rct

Introduction

Intrahospital cardiac arrest is an important cause of intrahospital mortality with a survival rate to discharge of approximately 25%[1], and one year adjusted survival rate of 13%.[2] Resuscitation and post-resuscitation survival rates have improved over the past decades, particularly for non-shockable rhythms, and rapid and high quality cardiopulmonary resuscitation (CPR) is believed to be essential for short and long term outcome for patients with cardiac arrest.[3] The International Liaison Committee on Resuscitation (ILCOR) and European Resuscitation Council (ERC) Guidelines provide recommendations for high quality CPR and underline the importance of implementation, education and training.[4–6]

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Traditional instructor led cardiopulmonary resuscitation (CPR) training is both cost and resource demanding, and novel methods are sought to improve training abilities and reduce cost.[7] Further, frequent training is needed as retention of CPR skills declines dependant on time since training, although the exact temporal curve of skill deterioration is unknown.[8–11]

CPR skill stations could provide means to meet the need for frequent training and retraining required in a hospital setting. Thus, the main objective of this study was to test the null hypothesis that there was no difference between instructor free skill station training (SS) compared to traditional instructor led training (IL). Secondary objectives were to evaluate skill retention at 2 and 8 months and the potential impact of additional retraining at 2 months.

Methods

Study design

The study was designed as a randomised controlled superiority trial and took place between September 2010 and July 2011. The study was approved by the Norwegian Centre for Research Data (NSD) application number 18-878. All participants signed a written informed consent.

The participants were grouped ward-wise into three groups which were subsequently randomised by PCJ and TH by drawing of lots to receive skill station (SS) or instructor-led (IL) training. A power analysis was performed which indicated 40 participants in each arm was necessary in order to detect a clinically significant difference of 20% in compression depth with a β 0.8 and α 0.05.

The first group received skill station training with re-training (SS-R) after 2 months, the second group skill station training without re-training (SS) and the third group was trained using a traditional instructor led session (IL). The study design is shown in Fig. 1.

Skill station training was performed using the Rescue Anne Skill Station (Laerdal Medical AS, Stavanger, Norway), a CPR skill training station without a human instructor. The system comprises a screen-based instruction module in addition to a manikin with sensors and voice feedback to the subject in training, and was set up similarly to what has previously been described.[12] Participants practiced compression and ventilation separately, with automated feedback until satisfactory skill performance was registered, followed by a minimum of three complete cycles. After completion of training the participants were given the option to go directly to the test or perform additional training prior to testing. Training and test data as well as adherence to the CPR-algorithm was automatically acquired by the system.

Instructor led training was a theoretic and practical course lasting a total of 120 minutes given as per hospital protocol using trained instructors. All CPR-instructors were enrolled from Ålesund hospital, departments of Anaesthesiology or Medicine. All instructors were experienced (>5 years) anaesthetic or intensive care nurses, or paramedics, and certified by Norwegian Resuscitation Council as Basic and Advanced CPR instructors.

Blinding of the participants was unfeasible due to the nature of the trial. The primary endpoint was compression depth, and an increase in compression depth of 20% was defined as clinically relevant. Secondary endpoints were compression frequency, percent correct compressions, hands-off time, leaning, ventilation volumes, ventilation time, percent correct ventilations and rate of passing the test.

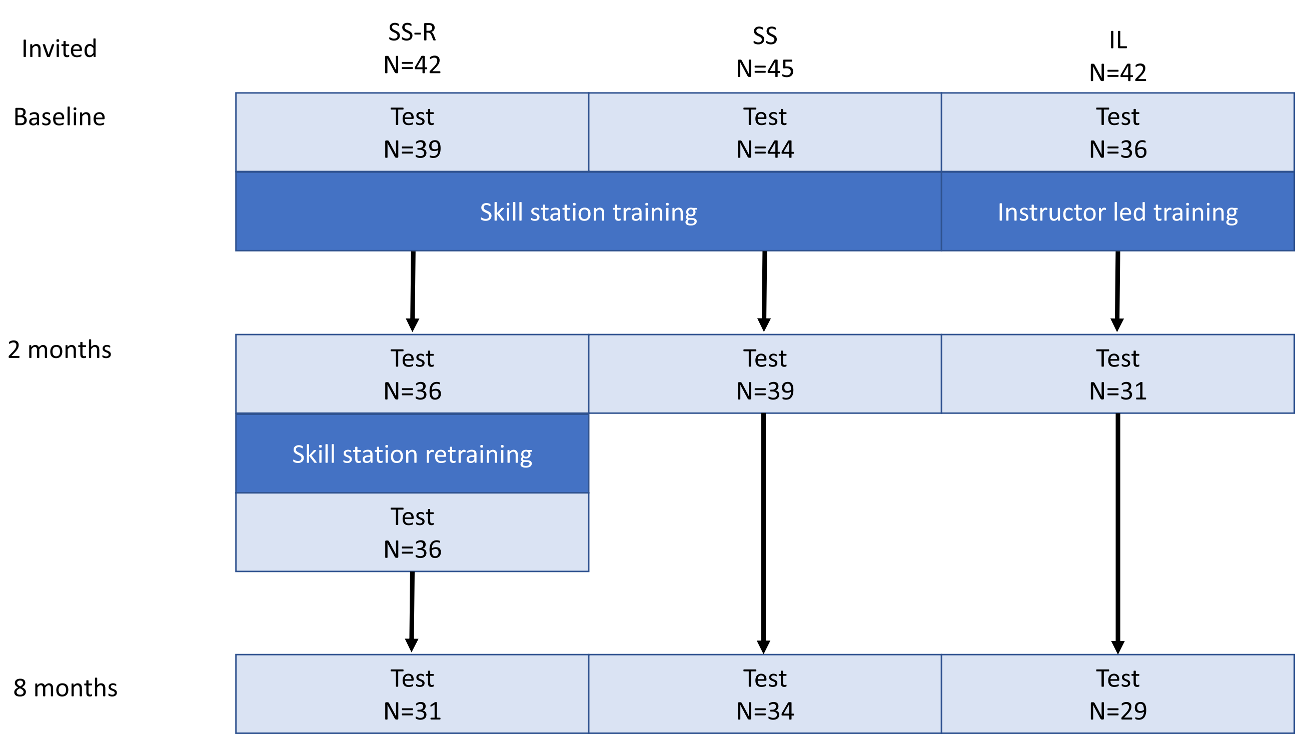

Fig. 1 – Participating nurses were groupwise randomised to three groups; skill station training with retraining at 2 months (SS-R), skill station training without retraining (SS) and instructor led training (IL). Reasons to loss to follow up was not recorded.

Each group was tested on three occasions; at baseline prior to retraining, at 2 months and 8 months. The tests were performed on the skill station without any feedback and each test consisted of 4 rounds of single rescuer CPR 30:2 where the last 3 rounds were exported for analysis. An instructor was present for introduction to the use of the skill station during the baseline testing, using a standardized script and without any additional instruction in CPR skills.

A final evaluation was performed at 8 months following baseline testing, which for SS and IL groups were 8 months following last CPR retraining. SS-R received retraining after the test at 2 months, and thus final evaluation was 6 months following last retraining for this group.

The three arms differed regarding mode of instruction and time since last retraining and thus the final test of SS-R and SS were compared to evaluate effect of re-training at 2 months. In order to raise the statistical power, the skill station groups SS-R and SS were pooled to a combined SS group (c-SS) for comparison to IL for evaluation of the different modalities of training at baseline and the two month retention test, however for the final test only SS and IL groups were compared in order to avoid bias related to the 2 month retraining.

Study population

All participants were certified nurses (N = 129), from 7 different hospital wards at Ålesund hospital selected to reflect a wide variety of clinical backgrounds. Of the nurses invited to the study, 119 participated at baseline registration (92.2%). The study population is described in Table 1. All participants were previously trained in basal CPR as per the standard method at the hospital, i.e. instructor led training. Due to loss to follow-up the groups comprised 42, 45 and 42 participants at inclusion, 39, 44 and 36 at baseline, 36, 39, 31 at 2 months and 31, 34 and 29 at 8 months for SS-R, SS and IL groups, respectively. Reasons for loss to follow-up were not recorded.

CPR skill quality parameters

CPR skill performance data was automatically detected using the skill station and exported for subsequent analysis.[12] The following parameters were registered and used to assess CPR quality; Compression frequency per minute, compression depth in millimetres, complete release, proportion of correct compressions (as defined by a compression depth of 41–63 mm with a frequency of 90–120 per minute without leaning > 7 mm), ventilation volume in millilitres, proportion of correct ventilation volume (as defined by volumes of 400–1000 millilitres), hands-off time in milliseconds per compression cycle, proportion of correct ventilation time (as defined by 1 (0.5–2) second ventilation time, 2 seconds pause and maximum 15 seconds hands-off time. Absolute number and proportion of participants passing the test was also recorded as defined by pass criteria (>0.7) completing three registered cycles of 30 (27–35) correct compressions followed by 2 correct ventilations with acceptable hands-off time and without leaning.

Statistial analysis

Independent samples t-test was used to compare means across study arms. Paired t-test was used to compare skill retention as means within study arms. Chi-square test was used to compare categorical variables. Mean and corresponding standard deviation was used to describe continuous variables, and frequencies and relative frequencies were used to describe categorical variables. Multiple testing correction was not performed. All analyses were performed using STATA version 15.0

Results

Baseline CPR skill performance

The groups were tested at baseline prior to retraining. Due to non-stratified randomisation the groups differed regarding time since last CPR training as shown in Table 1. Mean time since last training was 8, 14 and 11 months for the SS-R, SS and IL group (N = 119, p = 0.02), respectively.

CPR performance skills and groupwise skill retention are presented in Table 2. CPR skill differed significantly at the baseline test regarding mean compression frequency (102, 112, and 106 /min for SS-R, SS and IL, respectively, N = 119, p = 0.03), proportion of correct compressions (0.4, 0.2 and 0.4, respectively, p = 0.03), mean ventilation volumes (649, 613 and 875 ml, respectively, p = 0.001), mean proportion of correct ventilations (0.7, 0.4 and 0.4, respectively, p < 0.001) and participants who passed the baseline test (5/39, 00/44 and 1/36, p = 0.02). Compression depth and hands-off time were statistically similar between the groups.

The combined skill station group c-SS was statistically equal to IL at baseline with the exception of mean proportion of correct ventilations (N = 119, p = 0.02)

Table 1 – Baseline characteristics of the study participants in the three groups; skill station with retraining at 2 months (SS-R), skill station without retraining (SS) and instructor led training (IL). All participants were previously trained in basal CPR as per the standard method at the hospital, i.e. instructor led training.

	Skill station retraining (SS-R)	Skill station (SS)	Instructor led (IL)	
Number of participants	39	44	36	
Mean age (std)	40.7 (10.6)	41.0 (11.0)	36.3 (11.2)	p = 0.12
Males:Females (ratio)	2:37 (0.05)	2:42 (0.05)	3:33 (0.09)	p = 0.75
Average number of months since last standard CPR retraining at baseline	8 (10)	14 (8)	11 (7)	p = 0.02
Lost to follow-up (2 months)	3 (7.7%)	5 (11.4%)	3 (8.3%)	p = 0.83
Lost to follow-up (6 months)	6 (15.4%)	8 (18.2%)	8 (22.2%)	p = 0.75

Table 2 – Skill quality parameters for compressions, ventilations and over-all test results are presented for the three groups skill station with retraining at 2 months (SS-R), skill station without retraining (SS) and instructor led training (IL) at baseline, test at 2 months and 8 months. Quality parameters are also displayed for the SS-R group tested immediately following the 2 month retraining. Longitudinal analysis using paired samples t-test, * significant at the p < 0,05 level, ** significant at the p < 0.01 level and * significant at the p < 0.001 level.**

		Group	Baseline	2 months	2 months versus baseline (p-values)	2 months test following retraining	2 months test versus retest (p-values)	8 months	8 months versus baseline (p-values)	8 months versus 2 months (p-values)
Compressions	Frequency compressions pr min.	SS-R	102 (16.1)	100 (8.1)	*0.94*	105 (7.6)	*0.001***	98 (11.0)	*0.54*	*0.60*
		SS	112 (18.8)	111 (11.4)	*0.87*			111 (11.8)	*0.90*	*0.88*
		IL	106 (18.6)	108 (11.7)	*0.89*			106 (17.1)	*0.16*	*0.10*
	Depth mm	SS-R	44.4 (8.6)	45.0 (6.4)	*0.66*	48.7 (4.3)	*<0.001****	47.8 (6.6)	*0.02**	*0.02**
		SS	45.8 (7.9)	45.7(7.9)	*0.36*			46.6 (8.7)	*0.20*	*0.71*
		IL	46.3 (7.8)	44.9 (7.6)	*0.72*			45.8 (9.5)	*0.53*	*0.85*
	Proportion of compressions with leaning	SS-R	0.049 (0.10)	0.001 (0.01)	*0.03**	0.002 (0.01)	*0.52*	0.006 (0.02)	*0.05*	*0.24*
		SS	0.052 (0.18)	0.012 (0.05)	*0.14*			0.013 (0.06)	*0.08*	*0.98*
		IL	0.005 (0.01)	0.013 (0.06)	*0.49*			0.031 (0.12)	*0.24*	*0.13*
	Proportion correct compressions	SS-R	0.39 (0.36)	0.57 (0.36)	*0.05*	0.96 (0.05)	*<0.001****	0.45 (0.37)	*0.49*	*0.08*
		SS	0.21 (0.26)	0.47 (0.41)	*0.001***			0.43 (0.04)	*0.008***	*0.65*
		IL	0.36 (0.37)	0.46 (0.37)	*0.15*			0.34 (0.40)	*0.44*	*0.09*
Ventilations	Volume ml	SS-R	649 (270)	591 (221)	*0.24*	716 (145)	*<0.001****	646 (183)	*0.84*	*0.06*
		SS	614 (334)	629 (196)	*0.32*			649 (198)	*0.05*	*0.53*
		IL	875 (382)	723 (316)	*0.04**			697 (261)	*0.01**	*0.66*
	Proportion correct ventilation time	SS-R	0.85 (0.22)	0.83 (0.28)	*0.70*	0.94 (0.18)	*0.02**	0.87 (0.15)	*0.694*	*0.18*
		SS	0.70 (0.31)	0.88 (0.19)	*0.003***			0.80 (0.26)	*0.047**	*0.13*
		IL	0.80 (0.30)	0.80 (0.34)	*0.77*			0.73 (0.30)	*0.40*	*0.27*
	Proportion correct ventilations	SS-R	0.71 (0.29)	0.71 (0.32)	*0.91*	0.91 (0.19)	*<0.001****	0.75 (0.24)	*0.60*	*0.31*
		SS	0.41 (0.31)	0.72 (0.34)	*<0.001****			0.71 (0.31)	*0.001***	*0.92*
		IL	0.40 (0.37)	0.65 (0.38)	*0.01**			0.54 (0.36)	*0.16*	*0.11*
	Hands-off time ms	SS-R	10488 (3643)	9709 (2241)	*0.34*	8966 (3030)	*0.10*	9894 (3416)	*0.60*	*0.37*
		SS	12286 (5372)	9886 (3794)	*0.01**			9811 (2312)	*0.002***	*0.70*
		IL	11135 (4330)	9739 (3867)	*0.12*			10310 (3965)	*0.26*	*0.58*
Passed test	N (%)	SS-R	5/39 (12.8%)	8/36 (22.2%)	*0.28*	35/36 (97.2%)	*<0.001****	5/31 (16.1%)	*0.69*	*0.53*
		SS	0/44 (0.0%)	8/39 (20.5%)	*0.001***			6/34 (17.6%)	*0.004***	*0.63*
		IL	1/36 (2.7%)	6/31 (19.3%)	*0.03**			2/29 (6.9%)	*0.43*	*0.17*

Skill retention

Two months after the initial instruction the participants were tested for skill retention. The groups receiving different training modalities, c-SS and IL, performed equal for all investigated parameters, except for mean ventilation volumes which were adequate for both groups but was significantly higher for the IL group (610 and 723 ml, N = 106, p = 0.03). The overall proportion of participants who passed the test was also statistically equal (16/75 and 6/31, p = 0.69).

At the final evaluation SS-R performed statistically similar to SS for all measured CPR parameters, except for a significantly lower compression rate (98 vs 111 compressions/min, N = 65, p < 0.001). When comparing longitudinally, the intragroup compression frequency was not significantly different for any of the given groups. SS-R was the only group who had deeper compressions at 8 months compared to testing at baseline and at 8 months compared to the test at 2 months with an increase in compression depth of 3.4 mm (7.6%, N = 36, p = 0.02) and 2.8 mm (6.3%, N = 31, p = 0.02), respectively. No additional benefit of retraining at 2 months could be seen at the final test.

When comparing CPR quality at the final evaluation at 8 months SS performed a higher proportion of correct ventilations compared to IL (71% and 54% respectively, N = 63, p = 0.04). The remaining CPR quality parameters were statistically similar between the two groups.

Skill quality immediately following skill station retraining

In accordance with study design SS-R was given an additional instructor free skill station retraining following the initial 2-month test. SS-R was tested immediately following this retraining, and this test showed highly significant improvement in all measured parameters, and the number of tested participants who passed the test increased from 8/36 pre-training to 35/36 immediately post-training, as shown in Table 2.

Discussion

The main finding of this study is that CPR skill performance for hospital nurses using a skill station for recertification was similar to instructor led training both at 2 and 8 months following recertification. Training retention at 2 months following retraining was remarkably uniform, with approximately 20% passing the test regardless of randomisation to retraining modality. In consistence with this, all measured skill parameters except ventilation volumes were statistically similar across the groups at the 2-month test.

The primary outcome of our study was to evaluate if a significant improvement in chest compressions could be detected, as the depth and frequency of chest compressions are important factors in successful CPR and post resuscitation outcome. The 2010 ILCOR and ERC guidelines[13,14] were published October 2010, just after study initiation and recommended a stronger focus on chest compressions with an aim for frequency > 100 per minute and compression depth > 5 cm which is stricter than the CPR metrics used in this study. Subsequent to the design of this trial, a difference in chest compressions of 5 mm has been found to be of relevance in overall survival and favourable outcome.[15] In line with this, our study is underpowered to detect a difference in chest compressions as low as 10% between the groups.

Training retention at 8 months following baseline was mainly similar between the groups, with exception of a significantly higher proportion of correct ventilations in the SS group compared to IL. It should also be noted that the overall test pass proportion was approximately 17% at final evaluation for both SS-R and SS groups as compared to 7% for the instructor-led group at 8 months, although this was not statistically significant. A pooled comparison of the c-SS to IL at final evaluation was not part of the study design as it might risk a bias following retraining for half of the participants at 2 months.

The overall test pass rate for the study was generally low and could be related to the stringent test pass criteria. Skill reporter systems have been shown to be more accurate but also less lenient than observer ratings.[16] However, real world data suggest that CPR quality often fall below guideline standards.[17,18] Direct comparison to other studies on CPR skill quality of nurses is hampered by differences in timing of evaluation and reported parameters, and there is a call for more standardization of data reporting from studies of CPR quality in order to facilitate summarised reviews and meta-analyses.[8,19] It is well established that technical CPR skills are easily mastered immediately following training, and this was clearly demonstrated under the same pass criteria in our study for the SS-R group following the 2 month retraining. Following training the skills deteriorate and typically return to baseline after approximately 1 year.[20,21] Although this study was not designed to find the optimal retraining interval, it may add knowledge to the ongoing debate. This study shows results at 2 months were overall superior to baseline, while results at final evaluation was somewhere in between baseline and 2 month test. This is in line with previous reviews suggesting that skills deteriorate rapidly in the interval between 6 weeks and 6 months after training.[8] Interesting to add to this was that the group who at baseline had the longest mean interval since last CPR retraining, the SS group who had 14 months since last retraining, was the only group who performed significantly better at retesting at 8 months compared to baseline. Further, when evaluating the mean time since last retraining, 5 out of 6 test passers out of all 119 participants at baseline were from the SS-R group who had the shortest time since last retraining, which was 8 months. This emphasizes the need for frequent retraining in critical skills like high quality CPR. CPR skill stations have been shown to be effective in both initial skill acquisition and could help identify health professionals in need of retraining.[22,23] Short refresher courses in between regular CPR courses have shown to improve skill retention for up to one year,[24] and CPR skill stations could offer an effective means of retaining skill competence by means of short refresher training for a few minutes monthly or every 2–3 months.[25,26] Even though the level of evidence is low, it is recommended that CPR training is part of an integrated program focusing on CPR quality, feedback, debriefing and data surveillance.[19]

The study was not registered at Clinicaltrials.gov or other clinical trial registries as it was not mandatory at the time the study was initiated and conducted. Another limitation to the study was that the randomisation of nurses was unbalanced with regard to time since last retraining and the groups displayed significantly different CPR skill quality at baseline. Compression frequency differed significantly between the groups at baseline, but were within the recommended guideline range, and thus this difference is considered to be without clinical significance. When skill station groups were pooled to c-SS compared to the IL group they were similar both regarding baseline performance and the 2-month test. In addition, skill performance level at two months following retraining was equal despite the difference at baseline performance in the different groups.

A further weakness to the study is that multiple testing correction was not included in the study design and this could lead to a false discovery rate, while a greater than expected loss to follow up at 8-months led to group sizes lower than the target 40 in each group, thus negatively impacting study power at final evaluation.

It has previously been debated that poor skill retention in CPR performers could be attributed to inconsistency by CPR instructors,[27] however instructors in this study were all highly qualified and adhered to national life support instructor recertification guidelines.

Conclusions

Retraining of CPR skills for hospital nurses using a CPR skill station led to equal CPR skill performance at 2 and 8 months compared to instructor led training. The only significant difference between the groups was a superior proportion of correct ventilations in the skill station group at 8 months for our population. Skill performance immediately following retraining was very good, however skill performance declined rapidly as previously shown. At 2 months overall test pass proportion was only approximately 20 %. Using feedback-providing skill stations could be a feasible tool to facilitate the frequent retraining needed for high quality CPR performance. Optimal retraining interval or alternative training regimens in order to optimize nurses CPR skill is still undetermined, but short refresher courses between regular trainings should be further investigated as a possible intervention to increase skill retention.

Authorship contributions

KS, TÅM and DALH analysed and interpreted data, drafted the article and approved of the final version, AUG participated in acquisition of data, critically revised the article and approved of the final version, PCJ and TH were responsible for the concept and design of the study, acquisition, analysis and interpretation of data, critically revised the article and approved of the final version.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2021.100157.

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