A Randomized Trial of Cardiopulmonary Resuscitation Training for Medical Students

Voice Advisory Mannequin Compared to Guidance Provided by an Instructor

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Introduction: Current European Resuscitation Guidelines 2010 recommend the use of prompt/feedback devices when training for cardiopulmonary resuscitation (CPR). We aimed to assess the quality of CPR training among second-year medical students with a voice advisory mannequin (VAM) compared to guidance provided by an instructor.
Methods: Forty-three students received a theoretical reminder about CPR followed by a 2-minute pretest on CPR (compressions/ventilations cycle) with Resusci Anne SkillReporter (Laerdal Medical). They were then randomized into a control group (n = 22), trained by an instructor for 4 minutes per student, and an intervention group (n = 21) trained individually with VAM CPR mannequin for 4 minutes. After training, the students performed a 2-minute posttest, with the same method as the pretest.
Results: Participants in the intervention group (VAM) performed more correct hand position (73% vs. 37%; P = 0.014) and tended to display better compression rate (124 min^{-1} vs. 135 min^{-1}; P = 0.089). In a stratified analyses by sex we found that only among women trained with VAM was there a significant improvement in compression depth before and after training (36 mm vs. 46 mm, P = 0.018) and in the percentage of insufficient compressions before and after training (56% vs. 15%; P = 0.021).
Conclusions: In comparison to the traditional training method involving an instructor, training medical students in CPR with VAM improves the quality of chest compressions in hand position and in compression rate applied to mannequins. Only among women was VAM shown to be superior in compression depth training. This technology reduces costs in 14% in our setup and might potentially release instructors' time for other activities. (*Sim Healthcare* 8:234–241, 2013)

Key Words: Cardiopulmonary resuscitation, CPR, Voice advisory mannequin, VAM

Coronary heart disease is considered the leading cause of death in the world,[1] and cardiac arrest is the mechanism responsible for 60% of those deaths.[2] Immediate action through cardiopulmonary resuscitation (CPR) can double or triple the survival rate after ventricular fibrillation in a nonhospital setup.[3] Chest compressions generate a small but critical blood flow to the brain and heart.[4] Therefore, new European Resuscitation Council (ERC) Guidelines for Resuscitation 2010 underlines the relevance of effective cardiac massage as a key predictor in the survival of patients experiencing a cardiac arrest.[3]

Cardiac massage is normally performed by people around the patient. How can we appropriately train them? The International Liaison Committee on Resuscitation group in charge of identifying key aspects in education and implementation related to the 2010 Guidelines in Resuscitation[5] stated that (1) educational interventions should be evaluated to ensure that they reliably achieve the learning objectives. The aim is to ensure that learners acquire and retain the skills and knowledge that will enable them to act correctly in actual cardiac arrests and improve the patient outcomes; (2) CPR prompt or feedback devices improve CPR skill acquisition and retention and should be considered during CPR training for laypeople and health care professionals;[6] and (3) basic and advanced life support knowledge and skills deteriorate in as little as 3 to 6 months. The use of frequent assessments will identify those individuals who require refresher training to help maintain their knowledge and skills.[6–8]

Training in CPR should be compulsory for all health care workers and should be introduced in undergraduate training as soon as possible.[9] Our university includes CPR training in the first year of undergraduate medical school (students of 18–19 years of age). Several authors recommend this early approach.[10]

Several studies suggest that voice advisory mannequin (VAM), a CPR training mannequin giving vocal prompts, can improve compression skills during training, compared to guidance provided by an instructor.[11–15] However, few randomized controlled trials have been conducted among

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undergraduate medical students, and they offered nonconclusive results.[16,17] Our aim was to identify the most effective chest compression skills training method (VAM vs. instructor) among medical students to objectively achieve high-quality CPR in basic life support.

METHODS

Study Design

This was a randomized (1:1), blinded observer, controlled, and parallel-group trial on the effect of training second-year medical school students on CPR with a VAM compared to the training performed by an advanced life support instructor (ALS instructor), conducted at the University of Navarra, Spain. A sample size of 20 participants per group was calculated, assuming a baseline of 33% for compressions performed with a correct depth at baseline and a rate of 77% after VAM,[14] with values for α and β of 0.05 and 0.2, respectively.

Subjects and Recruitment

In March 2011, all 200 second-year undergraduate medical school students were invited to participate in the trial. The previous year, approximately 12 months earlier, all of them had undertaken the course "Initiation to Clinical Practice" where they had received both theoretical and practical training on CPR. The practical component consisted of a CPR seminar involving a lecturer per 20 students, using the simulator Resusci Anne Torso Basic (Laerdal Medical, Stavanger, Norway). To obtain a homogeneous sample, we excluded participants who had undertaken any other type of CPR training in the period between the previously mentioned course and the trial. Several studies have shown that CPR skills decay within 3 to 6 months after initial training,[5,18–21] although other authors observed this change only 9 to 12 months after training.[22]

Of the 86 students who showed interest in the study and were not excluded, a sample of 46 was randomly selected with the random function in Excel (Microsoft Office 2003). A total of 43 students, 15 men and 27 women, attended the initial appointment, and only 1 was lost to follow-up during the study. All of them were 19- to 20-year-olds, from Spain, and white. All of them received a certificate stating their participation in the trial and incorporated the experience into their degree portfolio to be evaluated at the end of the degree in medicine.

Ethical Approval

The research protocol was submitted to the local research ethics committee, which waived the need for full ethical approval. All participants gave written informed consent. A plan for retraining was proposed in case of finding relevant differences among groups.

Study Protocol

The study took place during April 2011 in the simulation center, University of Navarra. It was conducted by an ALS instructor (Department of Anaesthesia, Clinic University of Navarra) and 2 lecturers from the medical school, following a predefined protocol (Fig. 1).

Theory Review and Pretraining

All participants received a 10-minute lesson by an ALS instructor reminding them of the principles of CPR described in the ERC 2005 guidelines[23] and explained to them the previous academic year. The 2010 resuscitation guidelines came out too late for us to ensure that all mannequins would indicate proper compression depth as per the new guidelines and also too late to ensure that all subjects would have received training on the new guidelines. Therefore, we conducted the study as per the 2005 guidelines. It included the compression-ventilation standard protocol (30:2) and specific indications about how to perform chest compressions and ventilations.

After that, they performed basic CPR according to the standard protocol of 30 compressions and 2 ventilations during 2 minutes with a CPR Simulator, Resusci Anne SkillReporter (Laerdal Medical), which offers a chronological and functional analysis of a learner's CPR performance. The following variables about the compressions were recorded: total number of compressions, compression rate per minute, compression depth in millimeter, appropriate compression depth (correct, excessive, or insufficient), correct hand position, and incomplete release. Although ventilations were also performed, we only show information on compressions for this analysis. SkillReporter screen and printed report with data were hidden from the participants so they were not prompted to modify their CPR technique based on the feedback provided on the screen while we were collecting data.

Randomization

Participants were randomly distributed in 2 groups (control and intervention) using the random function on Excel (Microsoft Office 2003). Control group (n = 22) received classical training with instructor, whereas the intervention group (n = 21) received training with VAM.

Training

In the control group, a certified ALS instructor trained the students in 3 groups of 6 to 8 students each. First, he performed the CPR in the exact way it should be done in a real situation following the ERC Guidelines for Resuscitation

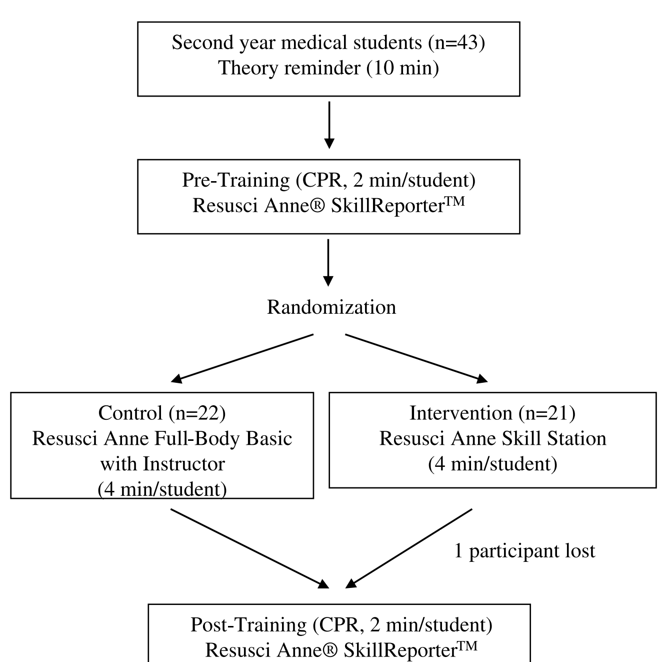

FIGURE 1. Flow chart of study protocol and participants.

FIGURE 2. Participant performing CPR training with the Resusci Anne Skill Station.

2005,[23] without explanation, in front of the students. Then, CPR was repeated, separating each of its components and explaining in detail how it should be done. Hand position, rate of compressions, and depth of compressions were explained. Each student practiced with the Resusci Anne Full-Body Basic (Laerdal Medical) for 4 minutes, while being corrected and advised by the instructor.

For the intervention group, each student trained individually with the VAM (Resusci Anne Skills Station, Laerdal Medical) for 4 minutes, receiving real-time feedback about the compressions and ventilations (Fig. 2).

For both groups, we based our variable selection and normal reference values on the ERC Guidelines for Resuscitation 2005[23]: compression rate between 90 and 120 min^{-1} and compression depth of 38 to 51 mm was assessed as correct, position of hand in the center of the chest was accepted, and incomplete release by more than 20% of total number of compressions was considered inappropriate.

Posttraining

After the training, all students performed a 2-minute practice of basic CPR with the Resusci Anne SkillReporter, and the same pretraining variables were gathered.

Statistical Analysis

Analyst was blinded to the control-intervention randomization groups. Groups were compared with χ^2 test and Fisher exact test when values were less than 5 for categorical variables and the Mann-Whitney *U* test for continuous variables (total number or percentage, depending on the variable). As secondary analysis, we assessed the effect of sex on the quality of chest compressions, both before and after the intervention.

RESULTS

Pretraining

Results from pretraining practice with the Resusci Anne SkillReporter did not show significant differences between control and intervention groups (Table 1). Both displayed higher compression rate than recommended, similar average compression depth, and correct hand position as well as similar number of compressions with incomplete release.

Posttraining

Different interventions led to differences in the effectiveness of CPR in posttraining assessment (Table 1). First of all, the VAM group showed a higher average number of compressions with correct hand position (73% vs. 37% for intervention and control group, respectively; $P = 0.014$). Second, the average compression rate was inappropriately high for both groups, compared with the 90 to 120 min^{-1} recommended by the 2005 guidelines. However, it was higher for control (instructor) group than for the intervention group (VAM): (135 min^{-1} vs. 124 min^{-1}; $P = 0.089$), suggesting a positive impact of VAM on reducing the natural tendency of students to use an excessively high compression rate. The rest of the parameters were similar in both groups. In a sensitivity analysis, *P* values did not change after adjustment for baseline total compressions through linear regression models (data not shown).

Intragroup Differences

Intragroup analyses (Table 2) showed improvement, after training, mainly in the VAM group (intervention): lower compression rate (132 min^{-1} pretraining vs. 124 min^{-1} posttraining, $P = 0.023$), greater average compression depth

TABLE 1. Resusci Anne SkillReporter Pretraining and Posttraining Results for the Control (Instructor) and the Intervention (VAM) Groups

	Pretraining			Posttraining		
	Control Group (Instructor)	Intervention Group (VAM)	P*	Control Group (Instructor)	Intervention Group (VAM)	P*
n	22	20		22	20	—
Female, n (%)	15 (68)	12 (60)	0.580	15 (68)	12 (60)	0.580
Total compressions, mean (SD)	187 (44)	177 (28)	0.231	170 (22)	150 (23)	0.001
Compression rate per minute, mean (SD)	140 (27)	132 (22)	0.290	135 (15)	124 (18)	0.089
Compression depth , mean (SD), mm	40 (12)	39 (10)	0.597	42 (8)	47 (7)	0.130
Average number of compression depth						
Correct, mean number (SD) [%]	82 (72) [44]	74 (61) [42]	0.900	89 (55) [52]	94 (53) [61]	0.420
Excessive, mean number (SD) [%]	44 (71) [22]	28 (48) [16]	0.332	32 (47) [18]	39 (53) [28]	0.488
Insufficient, mean number (SD) [%]	61 (80) [33]	75 (79) [42]	0.614	49 (62) [30]	17 (24) [10]	0.150
Average number of correct hand position, mean number (SD) [%]	104 (78) [58]	77 (83) [41]	0.146	62 (70) [37]	109 (58) [73]	0.014
Incomplete release, number [%]	4 [18]	1 [5]	0.203	3 [14]	2 [10]	0.547

*χ^2 test for categorical variables (Fisher exact test when values <5) and Mann-Whitney *U* test for continuous variables.

TABLE 2. Resusci Anne SkillReporter Intragroup Differences Pretraining and Posttraining

	Control Group (Instructor)			Intervention Group (VAM)		
n	22			20		
Female, n (%)	15 (68)			12 (60)		
	Pretraining	Posttraining	P*	Pretraining	Posttraining	P*
Total compressions, mean (SD)	187 (44)	170 (22)	0.042	177 (28)	150 (23)	0.001
Compression rate per minute, mean (SD)	140 (27)	135 (15)	0.270	132 (22)	124 (18)	0.023
Compression depth, mean (SD), mm	40 (12)	42 (8)	0.464	39 (10)	47 (7)	0.003
Average number of compression depth						
Correct, mean number (SD) [%]	82 (72) [44]	89 (55) [52]	0.538	74 (61) [42]	94 (53) [61]	0.225
Excessive, mean number (SD) [%]	44 (71) [22]	32 (47) [18]	0.196	28 (48) [16]	39 (53) [28]	0.139
Insufficient, mean number (SD) [%]	61 (80) [33]	49 (62) [30]	0.198	75 (79) [42]	17 (24) [10]	0.002
Average number of correct hand position, mean number (SD)[%]	104 (78) [58]	62 (70) [37]	0.038	77 (83) [41]	109 (58) [73]	0.126
Incomplete release, number [%]	4 [18]	3 [14]	0.317	1 [5]	2 [10]	0.564

*χ^2 test for categorical variables (Fisher exact test when values <5) and Mann-Whitney *U* test for continuous variables.

(39 mm pretraining vs. 47 mm posttraining, $P = 0.003$), and lower percentage of compressions with insufficient compression depth (42% pretraining vs. 10% posttraining, $P = 0.002$).

Stratified Analyses by Sex

Secondary analyses stratified by sex at baseline showed differences in pretraining assessment (sex stratified results pretraining not shown). Compression depth in millimeter was adequate in males but lower than expected in females (46 mm and 37 mm, respectively; $P = 0.015$). This result was confirmed by the average number of correct compression depth (57% in males and 35% in females; $P = 0.042$) and in the average number of insufficient compression depth (<38 mm) (15% in males and 49% in females, $P = 0.013$). The percentage of compressions with excessive depth (>51 mm) was higher among males (28%) than among females (16%) ($P = 0.035$). No pretraining differences were found in compression rate or in hand position in pretraining results when comparing males versus females.

In relation to the quality of posttraining compressions (Table 3), we found a significant improvement among women trained with VAM in both greater average compression depth (36 mm pretraining vs. 46 mm posttraining, $P = 0.018$) and in the decreased percentage of compressions with insufficient depth (56% pretraining vs. 15% posttraining, $P = 0.021$). Such effect was not found among males trained with VAM. Control groups, both among men and women, showed no significant differences. As sensitivity analysis, *P* values did not change after adjustment for baseline total compressions through linear regression models (data not shown).

DISCUSSION

Training medical students in CPR through VAM improves the quality of chest compressions in hand position and compression rate applied to mannequins compared to classical training with instructor. Only among women was VAM shown to be superior in compression depth training.

Yeung et al[6] concluded after a systematic review that "there is good evidence supporting the use of CPR feedback/prompt systems during CPR training to improve CPR skill acquisition and retention and that their use in clinical practice as part of an overall strategy to improve the quality of CPR might be beneficial."

Hand Position

The ERC guidelines recommend the following: "place the heel of your hand in the centre of the chest with the other hand on top."[23] We found that training with VAM is better for correct hand placement during compressions (73% vs. 37% for intervention and control group, respectively; $P = 0.014$). Isbye et al[17] found different results. They performed a clinical trial randomizing 42 second-year medical school students on the use of VAM versus instructor for adult CPR skill acquisition. They found no significant differences in the quality of chest compressions immediately after training in relation to correct hand position ($P = 0.21$). In addition, Oermann et al[12] found that students trained with VAM (n = 264) performed less amount of incorrect hand position compressions than those trained with instructor (n = 339) ($P = 0.01$). However, they randomized schools (n = 10), as opposed to individuals. These results are in line with our findings, although we should mention that their VAM intervention involved not only training with VAM as in our study but also computer-based didactic component including video lessons with realistic case scenarios.

Rate

The ERC 2005 guidelines state that a rescuer should compress the chest at a rate between 90 and 120 min^{-1}.[23] Our intervention group (VAM) came closer to those values than the control group (average of 124 min^{-1} vs. 135 min^{-1}, $P = 0.089$). A trial testing the use of VAM for pediatric CPR training among 50 lay persons[13] found that participants trained with VAM performed better compression rate ($P = 0.001$). A group study from the United States, randomizing nursing schools (not individuals) to either VAM or instructor training for adult CPR, found that among their 604 participants, there were no differences in compression rate.[22] Hostler et al[24] found in a randomized crossover trial (n = 114) that the use of VAM among prehospital providers with and without voice feedback did not directly improve compression rate.

Depth

The ERC 2005 guidelines[23] recommend a compression depth of 38 to 51 mm.[23] Some authors consider that some CPR performers tend to exert less depth than recommended owing to their lack of strength, fear of harm, and fatigue,

TABLE 3. Resusci Anne SkillReporter Pretraining and Posttraining Results for the Control (Instructor) and the Intervention (VAM) Groups Stratified by Sex

	Control Group (Instructor)						Intervention Group (VAM)					
	Males (n = 7)			Females (n = 15)			Males (n = 8)			Females (n = 12)		
	Pretraining	Posttraining	P*	Pretraining	Posttraining	P*	Pretraining	Posttraining	P*	Pretraining	Posttraining	P*
Total compressions, mean (SD)	179 (57)	171(28)	0.902	190 (38)	170 (19)	0.032	175 (14)	149 (18)	0.008	178 (35)	150 (27)	0.011
Compression rate per minute, mean (SD)	146 (37)	141 (23)	0.949	137 (23)	132 (11)	0.237	134 (23)	123 (18)	0.279	131 (23)	125 (18)	0.488
Compression depth, mean (SD), mm	47 (6)	49 (5)	0.805	37 (13)	39 (8)	0.693	44 (8)	48 (6)	0.429	36 (10)	46 (7)	0.018
Average number of correct depth, % (SD)	62 (15)	58 (10)	0.535	36 (9)	50 (9)	0.349	54 (10)	67 (14)	0.141	34 (10)	58 (8)	0.106
Average number of excessive depth, % (SD)	32 (16)	38 (12)	0.902	18 (8)	9 (5)	0.877	25 (12)	30 (15)	0.634	10 (6)	28 (11)	0.280
Average number of insufficient depth, % (SD)	5 (3)	5 (3)	0.535	46 (12)	41 (10)	0.950	21 (10)	3 (2)	0.248	56 (13)	15 (5)	0.021
Average number of correct hand position, % (SD)	73 (13)	58 (18)	0.805	51 (10)	27 (9)	0.146	50 (15)	83 (8)	0.081	36 (12)	66 (12)	0.137
Incomplete release, n (%)	4 (57)	3 (43)		0	0		1 (13)	1 (13)		0	1 (8)	

*χ^2 test for binomial variables (Fisher exact test when values <5) and Mann-Whitney U test for continuous variables.

despite the fact that no study has related damage derived from chest compressions to an excessive compression depth.[25] Our results on the sex differences on compressions depth at baseline are in agreement with previous studies. We found that at baseline, males performed higher proportion of compressions with correct depth and less proportion of compressions with incorrect depth, as compared with females. Some studies found an association between the weight and height of the CPR performer with the depth of the compressions performed.[26–28] In addition, it is generally accepted that males can apply more strength given their naturally higher muscular mass than females.[29] However, other studies found that compression depth did not strongly depend on sex, weight, or height.[30]

In relation to posttraining results (Table 3), we found that women trained with VAM showed a statistical significant improvement in average compression depth, compared with women trained by instructor. No previous studies have assessed the effect of VAM training separated by sex, but a study involving almost exclusively women showed this same effect in compression depth among students trained with HeartCode basic life support with VAM compared to instructor (n = 604) ($P = 0.006$).[22] In contrast, baseline results from the study performed by Isbye et al[17] including 68% females in the VAM group (n = 22) showed a basal average compression depth of 37 mm, whereas the instructor group (n = 21) including 52% females showed a basal average compression depth of 44 mm. However, they did not offer baseline *P* values for the groups or did not perform sensitivity analyses adjusting for baseline parameters. After training, the average compression depth were 49 and 50 mm in the VAM and instructor groups, respectively ($P = 0.38$). These negative results could be due to the different sex distribution at baseline. Finally, Wik et al[15] compared training of 24 paramedic students with VAM versus mannequin alone without audio feedback. They found that VAM improved compression depth ($P = 0.002$). However, they did not offer training with instructor.

Incomplete Release

The American Heart Association and ERC 2005[23] guidelines recommend complete chest wall decompression during CPR.[23] Venous return is produced in part owing to negative thoracic pressure; therefore, an insufficient decompression could lead to reduced blood flow into the chest, reduced coronary and brain perfusion, with reduced global CPR efficacy.[31] We did not find differences between groups in our study, and previous studies did not offer details about it.

Our study has some limitations. First of all, we defined normal compressions (rate, depth, hand position, and recoil) following the ERC Guidelines for Resuscitation 2005.[23] The rationale for that is that our simulators run both 2005 software and depth sensors. After we completed our study in September 2011, we updated software and hardware according to the ERC Guidelines for Resuscitation 2010 normal values.[3] Given the fact that the guidelines have changed, only a new study similar to the one described would evaluate the ability of students to effectively apply the new guidelines. The changes affect the normal compression depth of at least 5 cm, as opposed to the previous 38 to 51 mm, and the compression rate of at least 100 $\min^{-1}$ versus the 90 to 120 $\min^{-1}$ of the 2005 guidelines. Second, our sample size might be small to detect some effects. Despite that, we did find some positive associations, and we consider these to be important and useful results. Finally, another limitation in our study is that the baseline proportion of correct depth compressions was high (44% and 42% in the instructor and VAM groups, respectively). This could be the reason why we did not observe significant associations with the intervention and the proportion of compressions with correct depth. In addition, when we stratified the analysis by sex, we observed a significant improvement in correct depth among women trained with VAM (from 34% pretraining to 58% posttraining).

On the other hand, our study has a strong design, being a randomized, controlled, and parallel-group trial with blinded observer analysis. In addition, training preintervention was performed with the same type of simulator; therefore, results were not determined by a different evaluation method.

Finally, a gross economical calculation of our model (see Appendix 2) showed that 6 years training with VAM would cost €31,553 (€3.98 per student per year), assuming that a single mannequin lasts for at least 6 years. On the other hand, 6 years training with an instructor would cost €36,626 (€4.62 per student per year). This means that training with VAM costs 14% less than training with an instructor paid per hour, according to our model and our structure. Considering other scenarios (see Appendix 2), we defined a lowest-cost model where 6 years training with VAM would cost €31,553 (€3.98 per student per year), and training with an instructor would cost €19,800 (€3.62 per student per year). This means that training with VAM would costs 10% more than training with an instructor in the lowest-cost model. Finally, we also defined a highest-cost model where training with VAM would cost €33,166 (€4.18 per student per year), and training with an instructor would cost €43,981 (€5.55 per student per year) for a 6-year period. This means that training with VAM would costs 25% less than training with an instructor following the highest-cost model. Other models with different combination are possible.

In conclusion, compared to traditional training with instructors, using VAM to teach medical students CPR improves the quality of chest compressions in mannequins, with greater frequency of correct hand position and proper compression rate. Only among women VAM showed to be superior in compression depth training. This technology reduces costs in 14% in our setup and might potentially release instructors' time for other activities.

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APPENDIX 1:

In the 2010 European Resuscitation Council Guidelines for Resuscitation, optimal chest compression technique for an adult comprises the following:

Hand position. For adults receiving chest compressions, rescuers should place their hands on the lower half of the sternum. It is recommended that this location be taught in a simplified way, such as, "place the heel of your hand in the centre of the chest with the other hand on top."

Compression rate. The compression rate should be at least 100 min^{-1}, but not exceeding 120 min^{-1}.

Compression depth. Depth of at least 5 cm, but not exceeding 6 cm. There is evidence that a compression depth of 5 cm and greater results in a higher rate of return of spontaneous circulation, and there is no direct evidence that damage from chest compression is related to compression depth.

Chest decompression. Taking approximately the same amount of time for compression as relaxation, allowing complete recoil of the chest after each compression results in better venous return to the chest and may improve the effectiveness of CPR.

In the 2005 European Resuscitation Council Guidelines for Resuscitation, optimal chest compression technique for an adult comprises the following:

Hand position: "place the heel of your hand in the centre of the chest with the other hand on top."

Compression rate. The compression rate of approximately 100 min^{-1}.

Compression depth. Press down on the sternum 4 to 5 cm.

Chest decompression. Compression and release should take equal amounts of time.

Comparing 2005 with 2010 guidelines, principal changes are in the compression rate (from 100 min^{-1} to 100–120 min^{-1}) and the compression depth (from 4–5 cm to 5–6 cm).

We used the 2005 guidelines because by the time we started our study, we could not adapt both mannequin software and hardware (sensors) to the new 2010 recommended depth and our students had not been trained in the new parameters either.

We understand it is a limitation, but we believe that there is no reason to infer that a VAM-mannequin useful for teaching CPR to medical students following the 2005 ALS guidelines would not be useful for teaching CPR using the 2010 ALS guidelines. Although we believe the evidence offered by this clinical trial adds some useful information to medical education, only a new experiment could actually prove that the results for the 2005 guidelines also apply to the 2010 guidelines.

APPENDIX 2. Cost Analyses Comparison For a 6-Year Period

Lowest-Cost Model		Our Model		Highest-Cost Model	
Lower paid, per hour instructor (€25/H) Time per student (6 min)		Per hour Instructor (€35/H) Time per student (6 min)		Higher paid, full Time Instructor (€42.9/H) Time per student (6 min)	
Control		**Control**		**Control**	
Resusci Anne Full-Body SkillGuide	1529	Resusci Anne Full-Body SkillGuide	1529	Resusci Anne Full-Body SkillGuide	1529
Maintenance mannequin (5 y)*	2000	Maintenance mannequin (5 y)*	2000	Maintenance mannequin (5 y)*	2000
Overhead and basic personnel†	5377	Overhead and basic personnel†	5377	Overhead and basic personnel†	6990
Instructor‡	19,800	Instructor‡	27,720	Instructor‡	33,462
Total	28,706	Total	36,626	Total	43,981
Yearly§	4784	Yearly§	6104	Yearly§	7330
Per student per year‖	3.62	Per student per year‖	4.62	Per student per year‖	5.55
VAM		**VAM**		**VAM**	
Resusci Anne SkillReporter	20,000	Resusci Anne SkillReporter	20,000	Resusci Anne SkillReporter	20,000
Maintenance mannequin (5 y)*	4250	Maintenance mannequin (5 y)*	4250	Maintenance mannequin (5 y)*	4250
Software licenses	1926	Software licenses	1926	Software licenses	1926
Overhead and basic personnel†	5377	Overhead and basic personnel†	5377	Overhead and basic personnel†	6990
Total	31,553	Total	31,553	Total	33,166
Yearly§	5259	Yearly§	5259	Yearly§	5528
Per student per year‖	3.98	Per student per year‖	3.98	Per student per year‖	4.18

*First year maintenance is free of charge (included in the mannequin price).
†We have included basic simulation center personnel, general expenses (electricity, water, security, etc) and disposable equipment. In the highest-cost model, we added a 30% increase in overhead costs compared with our own model.
‡Instructor cost depends on being full time or per hour appointment. It also includes indirect cost (30%) in the case of the salaried full-time appointment.
§For a single year.
‖We have 1320 students at our medical school.