# THE IMPORTANCE OF TRAINING IN DELIVERING HIGH-QUALITY CHEST COMPRESSIONS

## *ZNAČAJ EDUKACIJE U POSTIZANJU VISOKOKVALITETNIH KOMPRESIJA GRUDNOG KOŠA*

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**Abstract**
**Introduction.** Sudden cardiac arrest is an abrupt cessation of the heartbeat, leading to a critical interruption in blood circulation and oxygen delivery to vital organs. Immediate initiation of cardiopulmonary resuscitation upon recognizing cardiac arrest significantly enhances the chances of survival. Basic Life Support helps to mitigate organ damage while awaiting more advanced medical interventions. The objective of this study is to evaluate the effectiveness of chest compressions delivered by students trained in Basic Life Support compared to those without such training. **Material and Methods.** A total of 120 first-year medical students participated in the study. Sixty students had not undergone Basic Life Support training, while the remaining 60 had successfully completed the course. Data about chest compression quality were gathered using SimPad PLUS Laerdal software and the Little Anne QCPR manikin. **Results.** Students who had received Basic Life Support training demonstrated significantly better performance across key parameters, including compression rate, depth, and the proportion of compressions meeting adequate depth criteria. Additionally, there was a statistically significant improvement in overall compression success rate among the students trained in Basic Life Support. **Conclusion.** The findings of this study highlighted the positive impact of Basic Life Support on the quality of chest compressions.
**Key words:** Heart Arrest; Cardiopulmonary Resuscitation; Education; Students, Medical; Heart Massage; Quality Improvement; Manikins; Life Support Care

**Sažetak**
**Uvod.** Iznenadni srčani zastoj predstavlja neočekivani prestanak rada srca koji dovodi do prekida krvotoka i snabdevanja organa kiseonikom. Započinjanje mera kardiopulmonalne reanimacije bez odlaganja, odmah nakon registrovanja znaka srčanog zastoja, povećava šanse za preživljavanjem. Osnovne mere oživljavanja usporiće razvoj oštećenja, dok se složenijim postupcima stručne medicinske pomoći ne obezbedi dalje zbrinjavanje. Cilj rada je analiza uspešnosti izvođenja visokokvalitetnih kompresija grudnog koša kod studenata nakon edukacije o osnovnoj životnoj podršci u odnosu na grupu studenata koji nisu prošli edukaciju. **Materijal i metode.** U istraživanju je učestvovalo 120 studenata prve godine medicine, od toga 60 studenata je činilo prvu grupu koja nije prošla edukaciju o osnovnoj životnoj podršci, dok se druga grupa sastojala od 60 studenata koji su prethodno prošli kurs. Za rad je upotrebljena lutka *Little Anne QCPR* uz korišćenje softvera (*SimPad PLUS Laerdal*) koji meri informacije o kvalitetu kompresija grudnog koša. **Rezultati.** Kada se razmatraju parametri kompresije grudnog koša, studenti grupe koja je prošla edukaciju o osnovnoj životnoj podršci pokazali su značajno bolje rezultate u brzini, dubini i procentu dovoljno dubokih kompresija. Studenti koji su prošli edukaciju pokazali su i statistički značajnu veću ukupnu uspešnost kompresija grudnog koša. **Zaključak.** Rezultati našeg istraživanja pokazali su da edukacija utiče na kvalitet kompresija grudnog koša.
**Ključne reči:** srčani zastoj; kardiopulmonalna reanimacija; edukacija; studenti medicine; masaža srca; unapređenje kvaliteta; lutke; osnovna životna podrška

## Introduction

Sudden cardiac arrest (SCA) is an abrupt cessation of the heartbeat, resulting in a loss of blood flow and oxygen to vital organs. Immediate resuscitation can potentially reverse the effects of SCA, but delays in starting resuscitation often lead to irreversible damage to the brain and other critical organs, ultimately causing death. Out-of-hospital survival rates for SCA are just below 10%, making it the third leading cause of death in developed countries [1–3]. Whether occurring in or out of the hospital, the treatment of cardiac arrest requires the rapid initiation of bystander cardiopulmonary resuscitation (CPR), with the primary goal of maintaining blood flow to essential organs, including the brain and heart. Survival chances increase two to threefold if CPR is started immediately following the onset of cardiac arrest [4, 5].

External chest compressions and artificial respiration, the key components of Basic Life Support (BLS),

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***Abbreviations***

| | |
|---|---|
| SCA | – sudden cardiac arrest |
| CPR | – cardiopulmonary resuscitation |
| BLS | – Basic Life Support |
| ERC | – European Resuscitation Council |
| ILCOR | – International Liaison Committee on Resuscitation |
| AHA | – American Heart Association |
| ROSC | – return of spontaneous circulation |

play a critical role in delaying heart and brain damage in individuals experiencing SCA. These interventions are designed to sustain vital organ functions until more advanced medical care can be provided by trained professionals. The effectiveness of CPR is largely determined by the quality of chest compressions, which depend on proper hand placement, depth, and compression rate. Full chest recoil after each compression is also crucial to maximize blood flow. Furthermore, maintaining continuous and uninterrupted compressions is essential for preserving coronary perfusion pressure, creating optimal conditions for successful resuscitation [6, 7].

Continuous education and training are necessary to ensure high-quality CPR. Advances in technology have led to the development of tools such as software applications, smartphones, and portable devices, which are integrated with training manikins to provide real-time feedback and quantitative assessment of CPR quality. These innovations aim to enhance the training process and improve CPR performance by offering immediate, accurate feedback on technique and effectiveness [8–10].

The aim of this study is to evaluate the effectiveness of delivering high-quality chest compressions in students trained in BLS compared to those without training.

## Material and Methods

This research was conducted at the Educational Center of the Institute for Emergency Medical Assistance in Novi Sad during November and December 2021. The study was approved by the Director of the Institute. Participants were first-year medical students from the Faculty of Medicine Novi Sad, who regularly attended first aid exercises. A total of 120 students, of both sexes, were included and divided into two groups of 60 each. Prior to the study, all participants were informed in detail about the study's objectives, methodologies, and the measurements involved. Students who declined to participate for any reason were excluded from the research.

The study included two different groups: the first group comprised students who had not received any BLS training, while the second group consisted of students who had completed a standard BLS course based on the 2021 European Resuscitation Council (ERC) guidelines as part of their first aid curriculum at the Faculty of Medicine. The training lasted four hours, focusing on practical application. Following the training, all participants underwent a formal skills assessment using the Laerdal Resusci Anne QCPR manikin and the ZOLL AED PRO defibrillator. The interval between the BLS training and the assessment ranged from 7 to 10 days.

After a brief introduction to the study equipment, each participant performed 2 minutes of chest compressions on the Laerdal Resusci Anne QCPR manikin. This manikin, designed specifically for BLS training, is integrated with the Laerdal SimPad PLUS software, which monitors and provides real-time feedback on the quality of chest compressions. Although the software can evaluate both ventilations and compressions, our study focused solely on chest compressions.

The data extracted from the software included: the total number of compressions performed in 2 minutes, the average compression rate per minute, the percentage of compressions delivered at the correct rate, the average depth of compression, the percentage of compressions that reached sufficient depth, the percentage of compressions with complete chest recoil, and the percentage of correct hand placements. The software then synthesized these parameters into an overall performance score, ranging from 0% to 100%, which reflected the quality of the chest compressions. The evaluation was based on the criteria outlined in the 2021 European Resuscitation Council Guidelines [6].

Data analysis was performed using IBM SPSS Statistics 23. Descriptive statistics, including mean and standard deviation, minimum and maximum values, or median and interquartile range (P25-P75), were calculated based on the normality of the data distribution, as assessed by the Shapiro-Wilk test.

Comparisons between the two groups were conducted using either the independent samples Student´s t-test or the Mann-Whitney U test, depending on the data's distribution. Gender differences were evaluated using the chi-squared ($\chi^2$) test. Results were presented in both tabular and graphical formats. A p-value of less than 0.05 was considered statistically significant.

## Results

A total of 120 participants were included in the study. Statistical analysis revealed a significant gender disparity, with a higher proportion of female participants (89; 74.2%) compared to male (31; 25.8%) ($\chi^2$ = 28.033, df = 1, p = 0.000). However, no statisti-

**Table 1.** ‡T-test with repeated measurements; *Mann-Whitney U* test; SD-Standard deviation*; IQR*- interquartile range: P25-25. percentile; P75-75. percentile; Bolded values are statistically significant.

| | Group 1 | Group 2 | Overall | p |
|---|---|---|---|---|
| Number of compressions | | | | |
| Mean±SD | 234.9±32.0 | 206.5±26.33 | 220.7±32.5 | <0.0001 |
| Min-Max | 163-307 | 150-262 | 150-307 | |
| Mean depth of all compressions (mm) | | | | |
| Median | 39.00 | 44.5 | 42.5 | 0.005 |
| IKR (P25-P75) | 22 (28-49.8) | 13 (37.2-50) | 16 (34-51) | |
| Mean speed of all compressions per minute | | | | |
| Mean±*SD* | 118.0±16.2 | 103.8±12.9 | 110.9±16.3 | <0.0001 |
| Min-Max | 82-154 | 78-131 | 78-154 | |
| Compressions at correct speed (%) | | | | |
| Median | 38.5 | 34 | 35.5 | 0.398 |
| IQR (P25-P75) | 82 (2-84) | 77 (9.2-86.5) | 80 (5.2-85) | |
| Correct hand position (%) | | | | |
| Median | 100 | 100 | 100 | 0.077 |
| IQR (P25-P75) | 0 (100-100) | 91 (9.5-100) | 23 (77.2-100) | |
| Compressions with complete chest recoil (%) | | | | |
| Median | 37.5 | 60 | 55.5 | 0.084 |
| IQR (P25-P75) | 88 (3-91) | 76 (17.2-93) | 84 (8.5-92.5) | |
| Sufficiently deep compressions (%) | | | | |
| Median | 2 | 11.5 | 5.5 | 0.003 |
| IQR (P25-P75) | 41 (0-41.2) | 49 (3-51.8) | 50 (0-49.5) | |
| Overall success (%) | | | | |
| Median | 9.5 | 25.5 | 17 | 0.003 |
| IQR (P25-P75) | 54 (0-53.8) | 75 (6.5-81.5) | 62 (3-64.8) | |

cally significant difference in gender distribution was observed between the two groups ($\chi^2 = 0.174$, df = 1, p = 0.677).

**Table 1** presents a descriptive statistics for the parameters examined. Only the variables "number of compressions" and "mean compression depth (mm)" followed a normal distribution. In the group of students without Basic Life Support (BLS) training (Group 1), the number of compressions ranged from 163 to 307, with a mean of 234.9 ± 32.0. In contrast, among the students who received BLS training (Group 2), the number of compressions was significantly lower (t = 5.308; p = 0.000), ranging from 150 to 262, with a mean of 206.5 ± 26.33. Additionally, the mean compression rate per minute was significantly lower in Group 2 (103.8 ± 12.9) compared to Group 1 (118.0 ± 16.2) (t = 5.302; p = 0.000), as shown in **Figure 1.**

The mean compression depth among students in Group 1 was 39 mm, whereas in Group 2, it was significantly higher at 44.5 mm (Z = -2.812, p = 0.005), as depicted in **Figure 2.**

The percentage of compressions performed at correct speed did not how a statistically significant difference between the two groups (Z = -0.846, p = 0.398), although the median value in Group 1 (38.5%) was slightly higher than in Group 2 (34%). Similarly, the percentage of compressions with complete chest recoil did not differ significantly between the groups (Z = -1.726, p = 0.084). In Group 1, half of the participants achieved 37.5% chest recoil, whereas in Group 2, half achieved 60%, as illustrated in **Figure 3.**

There was a statistically significant difference in achieving adequate compression depth (%) between students who had not undergone BLS training and those who had (Z = -2.995, p = 0.003). However, no

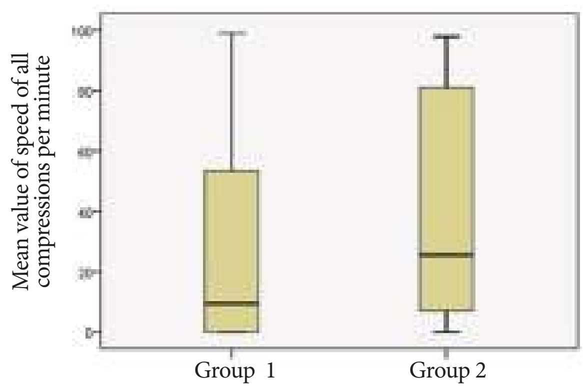


**Figure 1.** Mean value of the speed of all compressions per minute

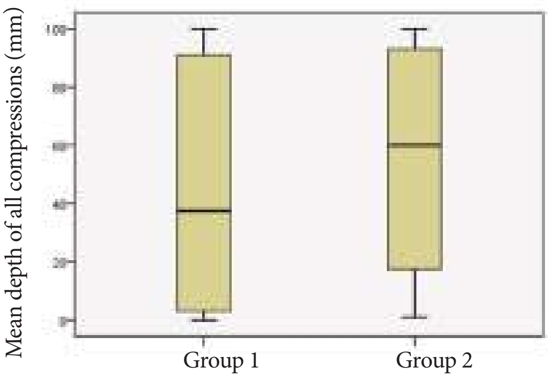


**Figure 2.** Mean depth of all compressions in mm

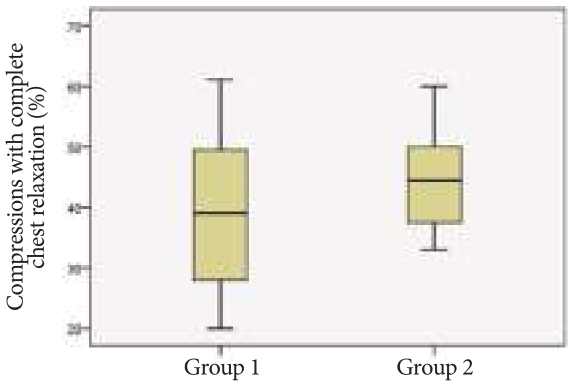


**Figure 3.** Compressions with complete chest relaxation (%) per group

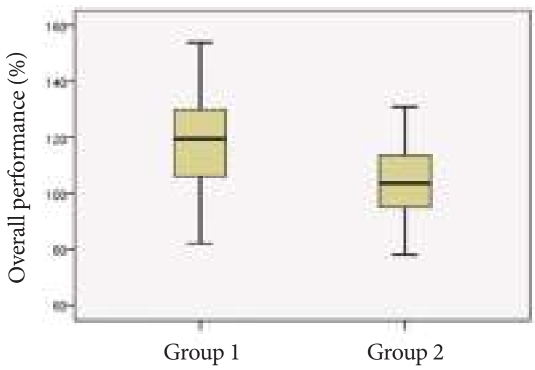


**Figure 4.** Mean value of speed of all compressions per minute

statistically significant difference was observed between the groups regarding hand positioning (%) during compressions (Z = -1.771, p = 0.077). Overall, participants who had completed the BLS course demonstrated a significantly higher overall success rate (%) compared to those without prior BLS training (Z = -2.934, p = 0.003), as illustrated in **Figure 4.**

## Discussion

CPR is a structured set of interventions aimed at restoring cardiac and respiratory function in individuals who have experienced cardiac arrest or respiratory failure. Immediate initiation of CPR at the scene is vital, following a predefined sequence known as the "chain of survival", which has been endorsed by the European Resuscitation Council (ERC) since 2005 [10]. The first link in the chain involves rapid recognition of the emergency and immediate activation of emergency medical services to prevent cardiac arrest. Subsequent links focus on early CPR and prompt defibrillation, followed by post-resuscitation care strategies to preserve vital organ function [11]. The 2020 Guidelines for Cardiopulmonary Resuscitation, based on research from the International Liaison Committee on Resuscitation (ILCOR), provide a widely accepted framework for effective and safe resuscitation practices [12].

Effective chest compressions are crucial for the survival of cardiac arrest victims [13–17]. The guidelines emphasize that high-quality compressions involve maintaining an appropriate rate and depth, ensuring full chest recoil, and positioning the hands correctly. Adherence to these parameters correlates with improved survival rates for both in-hospital and out-of-hospital cardiac arrest cases [13, 18]. Maintaining the correct rate and depth optimizes blood flow and oxygen delivery to the heart and brain, enhancing the likelihood of a return of spontaneous circulation (ROSC) and improving neurological outcomes at hospital discharge. In contrast, inadequate chest recoil impedes venous return, reducing mean arterial pressure and compromising perfusion in the coronary and cerebral circulations [11, 19, 20].

Despite widespread training in CPR, sudden cardiac arrest remains one of the leading causes of death in Europe, with resuscitation success rates below 10% [21]. Continuing education is essential to maintain and improve CPR skills, which can be enhanced through regular practice [22]. Technological advancements have transformed medical training with the introduction of tools such as mobile applications, smartwatches, and software devices designed to improve CPR training quality [8–10]. Studies consistently show that real-time feedback during CPR improves the depth and rate of compressions in both novice and experienced individuals [23–26].

This study aimed to evaluate the differences in the efficiency and quality of chest compressions between students who had completed a BLS course and those who had not. Participants performed compressions on a Laerdal Resusci Anne QCPR manikin connected to Laerdal's SimPad PLUS software, which measures and provides feedback on compression quality. The evaluation was based on ERC-recommended parameters such as compression rate, depth, full chest relaxation, and hand positioning. BLS-trained students demonstrated a statistically lower compression rate per minute compared to their untrained peers. However, their rates remained within the recommended range of 100 to 120 compressions per minute [13, 18]. The mean compression depth and the percentage of adequately deep compressions were also statistically significantly higher among BLS-trained students. Although participants did not achieve the guideline-recommended minimum compression depth of 50 mm, these results align with other studies conducted in training settings [27–30]. Vadeboncoeur et al. found that deeper compressions were associated with better survival outcomes in out-of-hospital cardiac arrest patients, with a mean compression depth of 49.8 ± 11.0 mm, and the mean rate of 113.9 ± 18.1 in min. Survivors had a significantly deeper mean compression depth (53.6 mm) compared to non-survivors (48.8 mm) [31]. In our study, no significant differences were observed between the groups concerning chest compression with full recoil and hand position. However, BLS-trained students had a statistically significantly higher overall compression success rate, as indicated by the SimPad PLUS software, which integrates all performance parameters into a comprehensive score ranging from 0 to 100%.

This study has several limitations. First, it was conducted using a manikin simulation, which do not replicate the real-world cardiac arrest situations, where panic and confusion can influence outcomes. Second, the study focused solely on chest compressions and did not consider ventilation, which is a critical aspect of CPR. Finally, some students in the non-BLS group may have had prior exposure to CPR techniques through secondary medical school or first aid courses, potentially influencing their performance.

## Conclusion

Our study highlights the vital role of training in enhancing the quality of chest compressions during cardiopulmonary resuscitation. Participants trained in Basic Life Support demonstrated superior performance in terms of compression rate, depth, and proportion of compressions reaching adequate depth. Additionally, those who had completed Basic Life Support training achieved a significantly higher overall success rate in delivering effective chest compressions.

Ongoing education and training are crucial for maintaining proficiency in cardiopulmonary resuscitation. Regularly updating and assessing acquired skills is essential for ensuring competence. Moreover, training in managing sudden cardiac arrest should extend beyond health care professionals to include the general population, fostering a broader level of competence and readiness for emergency situations.

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