*Acta Odontologica Scandinavica.* 2016; 74: 241–249



ORIGINAL ARTICLE

# Competency in managing cardiac arrest: A scenario-based evaluation of dental students

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**Abstract**

***Objective.*** Advanced Cardiovascular Life Support (ACLS) in life-threatening situations is perceived as a basic skill for dental professionals. However, medical emergency training in dental schools is often not standardized. The dental students' knowledge transfer to an ACLS setting thus remains questionable. The aim of the study was to evaluate dental pre-doctorate students' practical competence in ACLS in a standardized manner to enable the curriculum to be adapted to meet their particular needs. ***Materials and methods.*** Thirty dental students (age 25.47 ± 1.81; 16 male/14 female) in their last year of dental studies were randomly assigned to 15 teams. Students' ability to successfully manage ACLS was assessed by a scenario-based approach (training module: Laerdal® ALS Skillmaster). Competence was assessed by means of (a) an observation chart, (b) video analysis and (c) training module analysis (Laerdal HeartSim®4000; Version 1.4). The evaluation was conducted by a trained anesthesiologist with regard to the 2010 guidelines of the European Resuscitation Council (ERC). ***Results.*** Only five teams (33.3%) checked for all three vital functions (response, breathing and circulation). All teams initiated cardiopulmonary resuscitation (CPR). Only 54.12% of the compressions performed during CPR were sufficient. Four teams stopped the CPR after initiation. In total, 93% of the teams used the equipment for bag-valve-mask ventilation and 53.3% used the AED (Automated external defibrillator). ***Conclusions.*** ACLS training on a regular basis is necessary and, consistent with a close link between dentistry and medicine, should be a standardized part of the medical emergency curriculum for dental students with a specific focus on the deficiencies revealed in this study.

**Key Words:** *Dental curriculum, emergency treatment, life support, medical emergency*

## Introduction

Against the background of the demographic transition to an elderly population, the demand for primary management of medical emergencies through dental professionals is increasing in importance. With increasing life expectancy, the prevalence of multimorbidity and chronic diseases in geriatric patients will rise. Regular intake of medication and an increased number of sedations in the dental office add to a higher risk of dentists being confronted with ACLS in dental practice [1,2].

Worldwide studies indicate a non-negligible number of medical emergency cases in dental practice [3–6]. These medical emergencies can lead to life-threatening circumstances with the need for cardiopulmonary resuscitation. Recent studies point out the necessity to improve practical knowledge and skills with regard to medical emergencies in daily practice [7–10]. According to a German questionnaire in 2008, ~ 60% of the dental practitioners surveyed experienced up to three emergencies per year [7]. As dental professionals in the role of healthcare practitioners are obligated to provide professional first aid not only for ethical but also legal reasons [11], basic life support is seen as a fundamental skill requirement for dentists. According to the current guidelines for the graduating European dentist, a dental professional

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*(Received 23 July 2014; accepted 24 January 2015)*

ISSN 0001-6357 print/ISSN 1502-3850 online © 2015 Informa Healthcare
DOI: 10.3109/00016357.2015.1042782

should be capable of 'carrying out basic life support', as well as defibrillation for cardiac arrest [12]. Furthermore, in addition to basic life support (BLS), the American Heart Association recommends advanced cardiovascular life support (ACLS) as a standard for dentists, but does not explicitly mention defibrillation in the case of cardiac arrest [13]. In contrast, 49% of the dentists surveyed in Saxony, Germany, do not feel capable of conducting adequate BLS [7]. Dental students, in fact, feel unprepared when it comes to medical emergencies in general [14] and request more profound training in this area [15,16]. In particular, they seem to show a lack of skills in basic life support [16,17]. Practical knowledge about ACLS in particular is not adequately covered in most dentistry curriculums [16,18]. Being aware of these deficiencies, a standardized curriculum for emergencies in dental practice was proposed for implementation in dental schools by Mutzbauer et al. [9] as early as 1996. However, despite recent efforts in medical emergency training in dental schools, the curriculum often does not cover standardized guidelines. To sum it up, it remains a necessity in our opinion that students of dentistry should be prepared to deal with medical emergencies in clinical practice by having a standardized curriculum focused on the special needs of dentists and which reduces any personal reservations that may arise.

To implement an evidence-based curriculum in the field of medical emergencies, a systematic assessment of knowledge and skills in ACLS is needed. Clinical simulations are widely used in the context of objectively structured clinical examinations [19–21]. We argue that simulations are more valid in comparison with self-rating or to written exams when it comes to evaluating and assessing complex skills as opposed to factual knowledge [22]. Thus, a scenario-based simulation approach was used to assess students' skills in effectively managing emergency situations. The aim of this study was to investigate the performance of ACLS in dental students with a focus on parameters influencing the probability of survival: namely chest compression, no-flow time and handling of an Automated External Defibrillator (AED), this giving a standardized and evidence-based implementation of a medical emergency curriculum.

## Materials and methods

### *Participants*

The participants were 30 students in the fifth year of dental school studies that had already completed the theoretical and practical part of their professional education.

The cohort's mean age was 25.47 ± 1.81 years, with 16 male (53.33%) and 14 female students (46.67%).

### *Medical emergency education*

The traditional medical emergency course is a weekly 2-h lecture series on theory lasting 1 year and held at the beginning of the clinical part of the dental curriculum in the third year of study. The lectures are integrated with those for medical students at the university. The course ends with a written multiple-choice test on all taught aspects of medical emergencies. Course attendance and passing the written test is facultative.

### *Procedure*

Prior to the assessment of their practical skills, students reported their pre-education in medical emergency training using a cross-mark questionnaire. The questionnaire gave four options:

(1) never carried out first aid, (2) emergency course outside of the university including (2a) 8-h first aid course, (2b) 16-h first aid course or (3) membership in a professional medical emergency team. After filling out the questionnaire, students were randomly assigned to different teams. One student was randomly appointed as the team leader, while the other student would assist him/her. The teams were instructed to act with full autonomy of decision and competence as a qualified dentist would. A standardized procedure was used to inform the students about the setting prior to the assessment: Students read a description of the simulated situation in front of the closed door of the scene. The staff led the student team into the simulation room and drew the students' attention to the availability of the equipment as further described below. Students were informed they had free choice in using the equipment and that instructors were not allowed to give any advice to the teams. A detailed protocol for assessing these core skills was developed for that purpose (Table I). Two staff members of the Department of Anesthesiology and Emergency Medicine, both qualified in Advanced Life Support, rated each team member using a score sheet without influencing the work flow. The staff members underwent specific training in interpreting the score sheet and in emergency training assessment. If the score sheets were not in concordance with each other, the video analysis was consulted.

### *CPR setting*

The resuscitation scenario consisted of a Laerdal® ALS Skillmaster mannequin connected to a computer with Laerdal HeartSim® 4000 computer software version 1.4 (both by Laerdal, Stavanger, Norway). Heart rhythm was set to ventricular fibrillation (shock advised if using AED). The simulated setting was a waiting room in a dental practice with the mannequin

Table I. Protocol for CPR assessment.

| Member 1 Code:_______ | | | Team:______________ | | Member 2 Code:_______ | | |
|---|---|---|---|---|---|---|---|
| Sufficient | Not correct | Not provided | | | Sufficient | Not correct | Not provided |
| | | | Phase 1 | | | | |
| ☐ | ☐ | ☐ | Check for a response | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Shout for help | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Open airway/head tilt/chin lift | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Check oral cavity | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Check for breathing (look, listen and feel) | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Check for pulse | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Emergency call | | ☐ | ☐ | ☐ |
| | | | Phase 2 | | | | |
| ☐ | ☐ | ☐ | Lay the patient on a hard pad | Chest compressions | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Position of hands on the victim's sternum | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Arm position | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Depth of chest compressions | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Pressure is not applied over the victim's ribs or stomach | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Decompression | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Frequency | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Change of the positions (ventilation ←→ chest compressions after 3–5 min) | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Ratio 30:2 | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Chin lift | Breath | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Head tilt | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Effective rescue breath | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Using bag valve | | ☐ | ☐ | ☐ |
| ☐ | ☐ | ☐ | Using AED | | ☐ | ☐ | ☐ |

lying supine on the floor (Figure 1). The room was equipped with an automatic external defibrillator (Lifepak® 500T, Medtronic, Minneapolis, MN) as seen in Figure 2, a ventilation bag and a telephone for emergency calls (offering the possibility of talking to a simulated emergency control center).

*CPR assessment*

Three values were chosen for the assessment of the students' performance by the two staff members. The term 'sufficient' was defined by the standards corresponding to the current Guidelines of the European Resuscitation Council (ERC) [23]. If the process was conducted but not correct, the student's performance was labeled as 'insufficient'. Not performing an item at all was labeled as 'not realized'.

The CPR assessment was divided into two phases. The Diagnostic Phase (Phase 1) included the following six criteria adapted from Koster et al. [23]: Check for a response, call for help, check oral cavity, check breathing, palpate pulse and make an emergency call.

The Resuscitation Phase (Phase 2) starts with the first chest compression or ventilation and includes the treatment chosen by the team until it was stopped by the staff observers 10 min after the start of Phase 1. To examine the quality of CPR, an observation period of 180 s was chosen. The observation period was interrupted when students performed diagnostics or treatment other than CPR.

CPR results were reported by the Laerdal HeartSim software and comprised the number of correct and incorrect chest compressions and insufflations, the number of insufficient decompressions and the frequency of chest compressions. The method for calculating the no-flow time (NFT), defining the time of no chest compressions, was adapted from Jäntti et al. [24]. If an AED was used by the students, time for rhythm analysis was not considered as NFT.

*Statistics*

Homogeneity of variance and normal distribution were determined using Levene's test and the

Figure 1. ACLS scenario of dental students performing CPR.

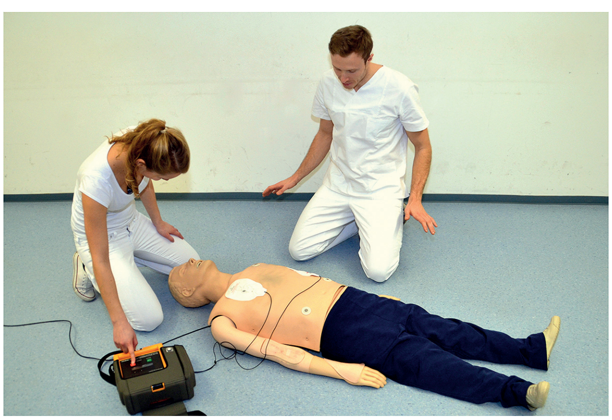

Figure 2. ACLS scenario of dental students using the AED.

Shapiro-Wilk test. The statistical pre-conditions are given for all tests conducted. Demographic data is presented in means and standard deviation. Student's t-test was used for the calculation of significant variations in parameters of AED usage. The non-parametric measurement of statistical dependence was performed using the Spearman rank correlation analysis. All statistical tests were performed using SPSS version 20 for Windows (IBM®, Armonk, NY). p-values ≤ 0.05 were considered to be statistically significant.

Table II. Description of the key data of the resuscitation.

| | Time (in seconds) from first contact with the patient until event occurs | | | | |
|---|---|---|---|---|---|
| | n | Mean | SD | Min | Max |
| Diagnosis of cardiac arrest | 30 | 34 | 33 | 6 | 125 |
| Emergency call | 24 | 93 | 85 | 10 | 285 |
| First thoracic compression | 30 | 69 | 61 | 13 | 238 |
| Use of AED (unless it was used) | 16 | 131 | 78 | 8 | 227 |

## Results

### *Prior knowledge and experience in CPR*

In total, 73.3% of the participants had never carried out first aid; however, 90% of the students had attended an emergency course outside of the university, while 63.3% had satisfactorily completed an 8-h first aid course and 20% a 16-h first aid course. None of the participants was affiliated with professional emergency activities.

### *Diagnostic CPR skills*

Five teams (33.3%) checked for all three vital functions (response, breathing and circulation), six teams (40%) checked no vital functions or only one vital function. A check for breathing was not performed by six teams (40%) and insufficiently performed by eight teams (53.3%, see Figure 3). This was mainly due to the lack of head tilt and/or chin lift by seven teams (87.5%, see Figure 4). Only 33% of the teams inspected the oral cavity for foreign bodies. A check for a pulse was performed by 12 teams (80%)—10 teams palpated the A. radialis (66.7%) and eight teams palpated the A. carotis (53.3%). When palpating the central pulse, five teams had investigated the wrong anatomical structure (outside of the trigonum caroticum). Of the teams that checked for a pulse, 33.3% used this as the only diagnostic device to detect the cardiac arrest (i.e. they did not check for consciousness or breathing). An emergency call was instigated by 73.3% of the teams. The median time of the call was 65 s after entering the scene (range = 15–261 s) (Table II). All calls included a description of a life-threatening situation for the patient. The diagnosis 'cardiac arrest' or CPR was named by only two teams (13.3%). Four teams did not call for emergency support (26.7%).

### *Therapy ACLS skills*

*CPR initiation and termination.* All teams initiated the CPR. Four teams (26.7%) conducted CPR at a ratio of 30:2 chest compressions to ventilations, while two

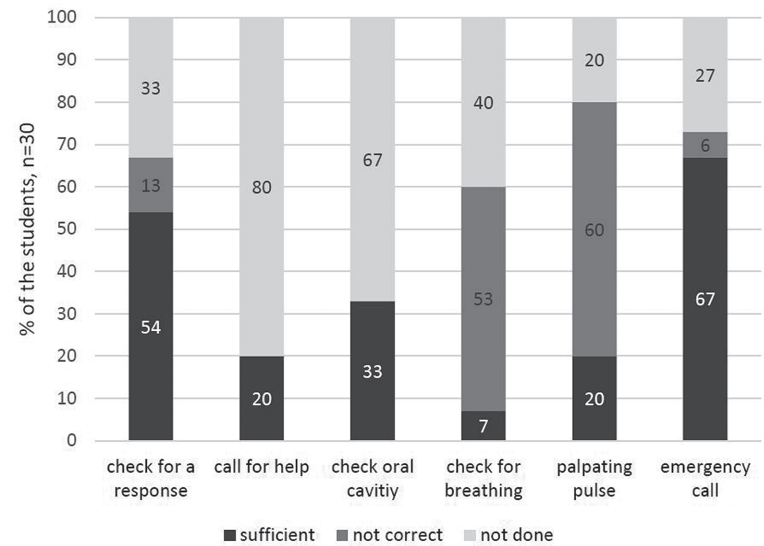


Figure 3. Skills before starting CPR according to ERC guidelines 2010; How students implemented these aspects.

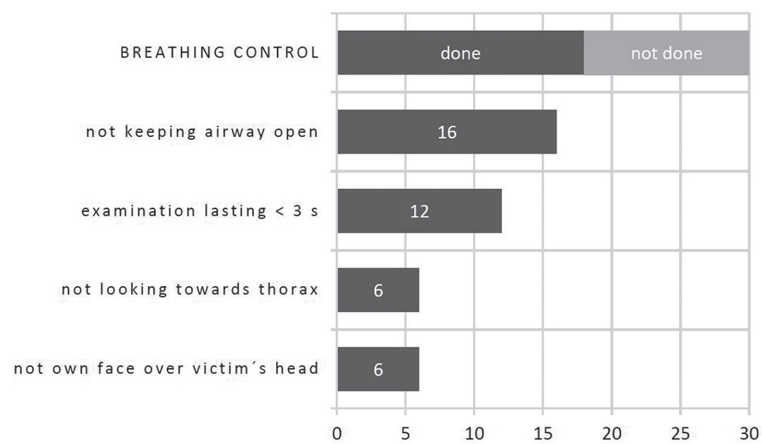


Figure 4. Sixty per cent of the students carried out a breathing check, but there were many mistakes, e.g. not keeping the airway open.

teams (13.3%) performed at a ratio of 15:2. Nine teams performed CPR at aberrant ratios. While 11 teams continued to perform CPR, four teams stopped CPR within the observed time period and changed the patient's position to a lateral recumbent position within, on average, 45 s after CPR. Although all students initially diagnosed the patient correctly with cardiac arrest and subsequently performed CPR, 25% deviated from this method after a mean of 42.67 ± 15.15 s and stopped administering CPR to the patient.

Assessment of the chest compressions for each student through the training module (Laerdal Heart-Sim® 4000; Version 1.4)

First thoracic compression was performed 69 s ± 61 after the first patient contact. The following assessment was conducted for each of the students: 40% of the students reached a compression rate of ≥ 100 per min as proposed by the ERC [23]. The minimum measured compression rate was 40, the maximum rate was 156 chest compressions per minute. In total, 54.12% of all chest compressions were evaluated as sufficient by the Laerdal Heart Sim Software.

*Assessment of oxygen supply.* In total, 93% of the teams used the equipment for bag-valve-mask ventilation. In 86.7% of the teams, an incorrect head position was repeatedly observed. Eighty per cent of the teams providing an oxygen supply did not regularly check thoracic excursions while ventilating (Figure 5).

*Assessment of AED usage.* In total, 53.3% of the teams used the automated external defibrillator (n = 8). On average, the AED was used after 131 s ± 78 (range = 8–227 s). The teams needed 59 s ± 24 (range = 23–103 s) from opening the cover until the first AED analysis was performed. Seventy-five per cent of the teams did not use any safety precautions while administering a shock. Seventy-five per cent of the teams performed CPR in the correct ratio

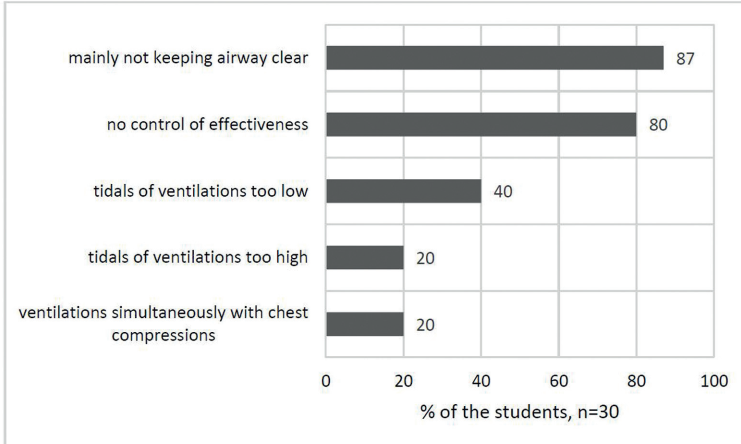


Figure 5. Mistakes of emergency ventilations.

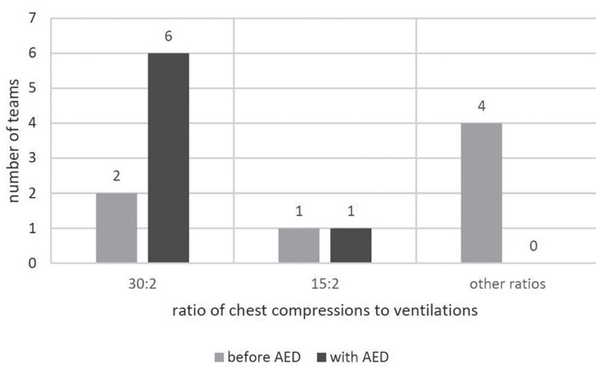


Figure 6. Ratio of chest compressions to ventilations changed significantly when using AED ($p < 0.05$; number of teams using AED: $n = 7$).

after self-correction (Figure 6). Teams using an AED provided a significantly higher amount of correct chest compressions, at 76.75% ± 4.88, than the teams that did not use an AED (23.95% ± 26.83; $p < 0.01$).

*Assessment of no-flow time (NFT)*. Mean NFT was measured at 54.02% ± 22.17 (min = 15. 56%, max = 93.33%). No-flow time of the non-AED users was 68.25% ± 21.26 (range = 40–93.33) and of the students who used an AED it was 41.06% ± 13.6 (range = 15.56–59.72) ($p < 0.01$).

## Discussion

In this study, an assessment of the procedural competence of fifth-year dentistry students on the subject of advanced cardiovascular life support (ACLS) was carried out. The core-skills in diagnosis as well as in therapy of a cardiac arrest were assessed through a detailed protocol including an observation chart, video analysis and training module analysis. According to the literature, a multi-perspective protocol to assess emergency competencies has not been carried out with dental students before. There is still an assumption of a lack of competence in emergency treatment by dental students, but no evidence of research into this question. However, there is a need for a specific curriculum for dental students and, therefore, the emergency curriculum for students of general medicine should not simply be copied. This study could show the specific needs of dental students in the 'worst case' emergency scenario of resuscitation. In the light of curriculum development, analysis of necessity of an educational system is one of the first steps [25]. Consequently, when considering a specific curriculum for dental students, the needs have to be known. Therefore, a very thorough approach was chosen in this study, showing a very poor performance in basic first aid skills at the end of dental studies.

For instance, the dental students' abilities to check for vital signs were insufficient. These results are similar to other studies where students and professionals were evaluated regarding breath and pulse check for cardiac arrest assessment [26–28]. While the majority of students palpated the radial pulse in the first place, the carotid pulse should be palpated by medical professionals, according to the 2010 ERC guidelines [23]. Hence, according to Deakin et al., palpating the central carotid pulse is advised as the peripheral pulse is not palpable in patients with blood pressures below 60 mmHg [26]. However, in this study, only the ability to palpate the correct anatomic location was evaluated, and it cannot be concluded whether an observable pulse could have been palpated. Even though the majority of the students palpated the peripheral pulse, this should not be advised in an emergency medical curriculum. The assessment of respiration was conducted sufficiently in only 60% of the cases. Mainly, the airway was not kept free during the examination. The rather low incidence of airway assessment for foreign bodies in the oral cavity was especially alarming in our cohort, since in dental practice there is a rather high probability of an airway blockage occurring due to foreign bodies such as prostheses or dental instruments, anaphylactic reactions or bleeding. A further critical point is seen in the duration of ventilation control, being under 3 s in six of 15 groups. Precise breath control is crucial because preliminary stages of apnea often result in insufficient agonal ventilation, e.g. gasping [23,29]. An insufficient check for breathing might, therefore, lead to a wrong interpretation. Thus, focusing on this aspect is recommended when teaching ACLS to dental students.

The compression rate is defined as the speed at which the chest compressions are performed [23]. Only 40% of the students were reaching the 2010 ERC compression rate of ≥ 100 per minute [23,30]. When the compression rate is lower than 100 per minute, as seen in 60% of the students, lower aortic peak pressures and coronary perfusion pressure can result [30], meaning sufficient oxygen supply and circulation cannot be ensured in the patient. Attaining this frequency is crucial because it is associated with a higher chance for the return of spontaneous circulation (ROSC) [30,31]. While there are no regulations about an upper limit of the chest compression rate, a limit of 120/min is currently recommended by the ERC guidelines [26,30].

Surprisingly in our study, 25% of the teams decided on their own to stop CPR, despite the necessity to continue CPR until death or the patient's circulation is confirmed. Stopping CPR in that situation would irrevocably impact the patient́s chance of survival. This shows a clear deficit and uncertainty in knowledge and training, even if the students demonstrated a rather sufficient performance of CPR. However, it could not be clarified within this study if these decisions were taken out of a lack of knowledge or a lack of practical training. Good performance in any practical training is based on knowledge, including procedural knowledge and practical skills. CPR is a complex competence, also based on knowledge and skills. Surely training also improves theoretical knowledge if thorough debriefing is conducted after the scenarios, but there is little evidence for the importance of trainings based on theoretical propaedeutic [32]. While for a specialist in emergency medicine it is clearly understood never to stop CPR, it is not so for novices in this context. Due to that, it can be stated that a hands-on course without having sufficient background medical knowledge would not adequately allow the students to conduct BLS. Outside of a simulated setting, there are scenarios which would further lead to a deviation from the algorithm. Therefore, a focus must be placed on clear and concise teaching that supports students in their actions and provides the necessary medical background for those actions.

Only four teams (26.7%) conducted CPR using the 30:2 chest compression-to-ventilation ratio. The 2010 ERC guidelines point out the increased emphasis on the importance of minimally interrupted high-quality chest compressions [26], which also accounts for minimizing the no-flow-time (NFT). In fact, the NFT is an important criterion for sufficient CPR and long-term survival. It is defined as the time without chest compressions [24,33]. The mean NFT in our cohort was 54%, which shows a considerably increased time span with regard to the optimal range seen in teams who train frequently [33]. However, the method of NFT calculation does not include the real hemodynamic effect of the CPR performed in this study. Measurement of the NFT in our case provides a reference for the quality of the CPR performance.

The majority of students chose the bag mask for ventilation purposes, with 60% conducting the ventilation correctly. This result underlines that bag mask ventilation requires considerable practice and skill [34]. However, bag mask ventilation is known to have a better neurological outcome compared to other airway devices [35] and can be taught satisfactorily to medical professionals.

Performing ACLS with an Automated External Defibrillator (AED) on site shows a significantly better outcome in patients experiencing cardiac arrest, as stated in the literature [36]. In accordance with that, students in our cohort using the AED had better results in no-flow time, more correct chest compressions and had a better ratio after AED usage. Although the use of an AED had never been demonstrated to the students prior to the study, > 50% implemented the AED in their BLS adequately. In fact, in 25% of the cases, both groups performed CPR at a 30:2 ratio before AED use. While AED non-users kept on conducting the same ratio during the simulation, 50% of the students who used the AED changed the CPR ratio into the currently proposed ratio of 30:2 [23]. Furthermore, no group interrupted CPR after using the AED. This result supports the proposed European Union guidelines, which recommend the teaching of defibrillation methods [12] and shows that this element is in fact helpful in training dental students in CPR.

However, some limitations of the study have to be considered as well. The student cohort followed the local curriculum, which assumes that also emergency medical competencies are taken into consideration. This study showed there is a need for a specific adoption of a dental emergency curriculum. Of course there is no direct evidence for other faculty emergency programs, even though they might be similar. This study focused only on CPR as a rare incident. Of course emergency competence for the dentist is more than performing resuscitation. On the other hand, the impact on the survival of a patient and the ethical implication as a medical specialist for a good performance in handling CPR are obvious. In consequence, a curriculum also has to be focused on this topic. We know there will be no clinical routine for CPR, and so the students need a long lasting training program on their specific needs.

## Conclusions

No team performed the CPR in a completely correct manner according to the ERC BLS-guidelines, even though the existing guidelines are meant to provide a sufficient framework for transferring theoretical to procedural knowledge. On the contrary, ethical and judicial demands require the adequate handling of medical emergency cases in dental practice. Based on the findings of our study, an evidence-based transfer from the existing medical emergency courses in ACLS with a focus on providing theoretical knowledge for a rather broad audience to case-specific, dentistry-related issues, including specific practical skills, should be established.

## Acknowledgments

This work was funded by ELAN-Funds University Erlangen-Nuremberg (AZ:11.03.09.1).

***Declaration of interest:*** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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