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Clinical paper

Time difference between pad placement in single versus double external defibrillation: A live patient simulation model

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Abstract

Background: Out-of-hospital cardiac arrest (OHCA) cause significant patient morbidity and mortality. Double sequential external defibrillation (DSED) represents an alternative treatment for OHCA patients, but the use is currently reserved for patients in refractory ventricular fibrillation. However, OHCA patients may achieve return of spontaneous circulation earlier with the use of DSED as initial treatment. This study compares the necessary times needed to establish pad placement in DSED compared to normal pad placement in a live patient simulation model.

Methods: This study was an observational cohort study with ambulance personnel and live patient models. The procedure was performed on two patient categories, with BMI 20.9 (patient A) and BMI 32.8 (patient B). Two-member teams established two defibrillators ready for rhythm analysis. Time spent for standard and DSED procedure was registered in the same procedure. All team members performed the procedure on both patient categories.

Results: In total, 108 procedures were performed on both patient categories. Mean time to standard pad placement was 24.6 ± 3.3 s for patient A, and 27.4 ± 3.7 s for patients B. Mean time to DSED pad placement was 38.3 ± 7.0 s for patient A, and 41.3 ± 7.4 s for patient B. Mean difference in time needed for DSED versus standard pad placement was 13.7 ± 4.8 s for patient A, and 13.9 ± 4.6 s for patient B. There was no significant difference in time spent between the two patient categories (p = 0.725).

Conclusion: The necessary time to establish DSED versus standard defibrillation pad placement was short. This may support clinical studies on DSED as initial treatment for OHCA patients without risk of significant increase in time to first defibrillation.

Keywords: Out-of-hospital cardiac arrest, Cardiopulmonary resuscitation, Defibrillation, Dual sequential external defibrillation

Introduction

Out-of-hospital cardiac arrest (OHCA) is a life-threatening event[1] with an estimated yearly incidence of 71/100 000 in Norway.[2] Despite survival factors such as witnessed cardiac arrest, early initiation of cardiopulmonary resuscitation, and early defibrillation,[3] only 14% of OHCA patients survive to 30 days.[2] The strongest predictor of survival of OHCA patients to discharge is in-field return of spontaneous circulation (ROSC),[3] hence immediate defibrillation is important in shockable rhythms. However, multiple defibrillations may be necessary to achieve ROSC. Studies suggest that more than 50% of patients with a shockable rhythm require more than two defibrillations to convert malignant arrhythmia,[1,4] while the chance of survival decreases for every failed shock.[5,6]

Double sequential external defibrillation (DSED) represents an alternative treatment for patients with refractory ventricular fibrillation (VF),[7–16] and is performed in ground ambulance services across

Abbreviations: AL, anterior lateral, AP, anterior posterior, BMI, body mass index, CPR, cardiopulmonary resuscitation, DSED, double sequential external defibrillation, OHCA, out of hospital cardiac arrest, ROSC, return of spontaneous circulation, SD, standard deviation, VF, ventricular fibrillation

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North America, Canada and New Zealand, while implementation continues across the world.[17] The procedure includes use of two defibrillators where the first set of pads are placed in the standard anterior-lateral (AL) position and the second set in the anterior-posterior (AP) position (Fig. 1). The shocks are administered in rapid succession, less than one second apart.[18]

One randomized controlled trial demonstrated that DSED increased survival for OHCA patients.[19] However, DSED was not performed until three standard attempts had failed, which delayed the alternative defibrillation strategy. It is currently unknown whether earlier DSED may lead to better outcomes than that seen with standard defibrillation. The time needed to place pads from two defibrillators compared to one defibrillator is also unknown. Therefore, we aimed to assess time needed to establish defibrillators in standard versus DSED procedure on a live patient simulation model.

Methods

Study location and participants

The study was performed over two days at Rosten ground ambulance station in Trondheim, Norway. The participants (12 male and 7 female) were ground ambulance personnel with experience levels ranging from trainee to advanced paramedics, and medical students from Norwegian University of Science and Technology, all trained in Advanced Life Support (ALS). All participants were introduced to DSED without any prior knowledge or experience of the procedure. The study program was repeated with a new group both days. Two male students were used as live patient models representing patients with different body mass index (BMI) categories; patient A with BMI of 20.9 (183 cm, 70 kg) and patient B with BMI of 32.8 (183 cm, 110 kg). Two study participants were dedicated to register time intervals on all performances.

Procedure

DSED is a continuation of the standard defibrillation procedure. Defibrillation pads 1a and 1b are placed in the AL position according to existing guidelines,[20] followed by placement of defibrillation pads 2a and 2b in the AP position (Fig. 1). Both procedures were evaluated and time registered in the same scenario. All participants were presented with the guidelines for both standard and DSED procedure (Fig. 2). This was followed by 45 min training on CPR mannequins (Resusci Anne QCPR, Laerdal Medical) allowing the participants to acquire confidence in the procedure. The participants were paired into two-member teams, and all teams performed the procedure on both patients. Necessary equipment for OHCA treatment, such as emergency bag with oxygen, medicine unit, and suction unit, in addition to two defibrillators (CorPuls3, Corpuls GS Elektromedizinische Geräte G. Stemple GmbH) were carried to the patient. The teams entered the room where the patient was lying on the floor unhindered by surrounding obstacles. The patient was dressed in a simple button-up shirt opened every scenario that would represent time spent cutting clothes. One team member confirmed cardiac arrest and initiated CPR by holding arms in chest compression position without administering actual downward pressure. The other team member placed both sets of defibrillator pads, starting with pads 1a and 1b, continuing without delay to place pad 2a on the patient's sternum. While CPR was continued, pad 2b was readied. Then the patient was logrolled onto CPR-performer and the pad was placed on the lower left scapula and CPR was continued (Fig. 3). The pause in CPR when placing both pad 2a and 2b was too quick to measure accurately in our study. No defibrillators were activated during the scenario. Brief feedback on patient handling or pad placement was given prior to the next repetition.

We found that the most efficient technique to expose the patient's lower left scapula, was for the CPR-performer to grab the patient's left hip with both hands and lift the hip off the ground by pulling the patient towards themselves. The other team member would push the patient's back further to gain access, if needed, before pad 2b was placed.

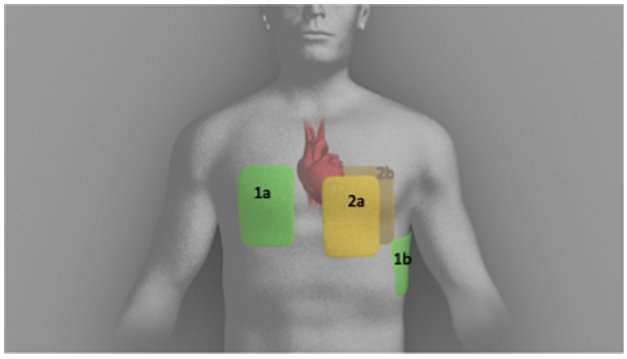

Fig. 1 – Position of pads in double sequential external defibrillation. The standard placement shown in green pads (1a and 1b), anterior-posterior position with a second defibrillator shown in yellow (2a and 2b). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Time intervals measured

Each scenario included three timed elements: time to CPR initiation, time to rhythm analysis using standard pad placement and in DSED placement. The timer started when the team entered the room. First time registered was "cardiac arrest confirmed, CPR initiated". Second time registered was "first defibrillator attached with both pads (1a + 1b)," simulating rhythm analysis in standard procedure. Third time registered was "second defibrillator attached with both pads (2a + 2b)", simulating rhythm analysis in DSED procedure.

Statistical analysis

Data analyses were performed with SPSS and Excel. All data are descriptive and presented as mean values with standard deviation (SD) and/or range, as appropriate. Student T-test was performed to assess time difference between patient A and B. *P*-value <0.05 was regarded as statistically significant.

This study is presented according to the strengthening the reporting of observational studies in epidemiology (STROBE) guidelines.[21]

Ethics

The study was approved by the Norwegian Regional Committee for Medical and Health research Ethics (reference 738916). All participants received information about the study and provided a written consent for use of pictures and data Fig. 3.

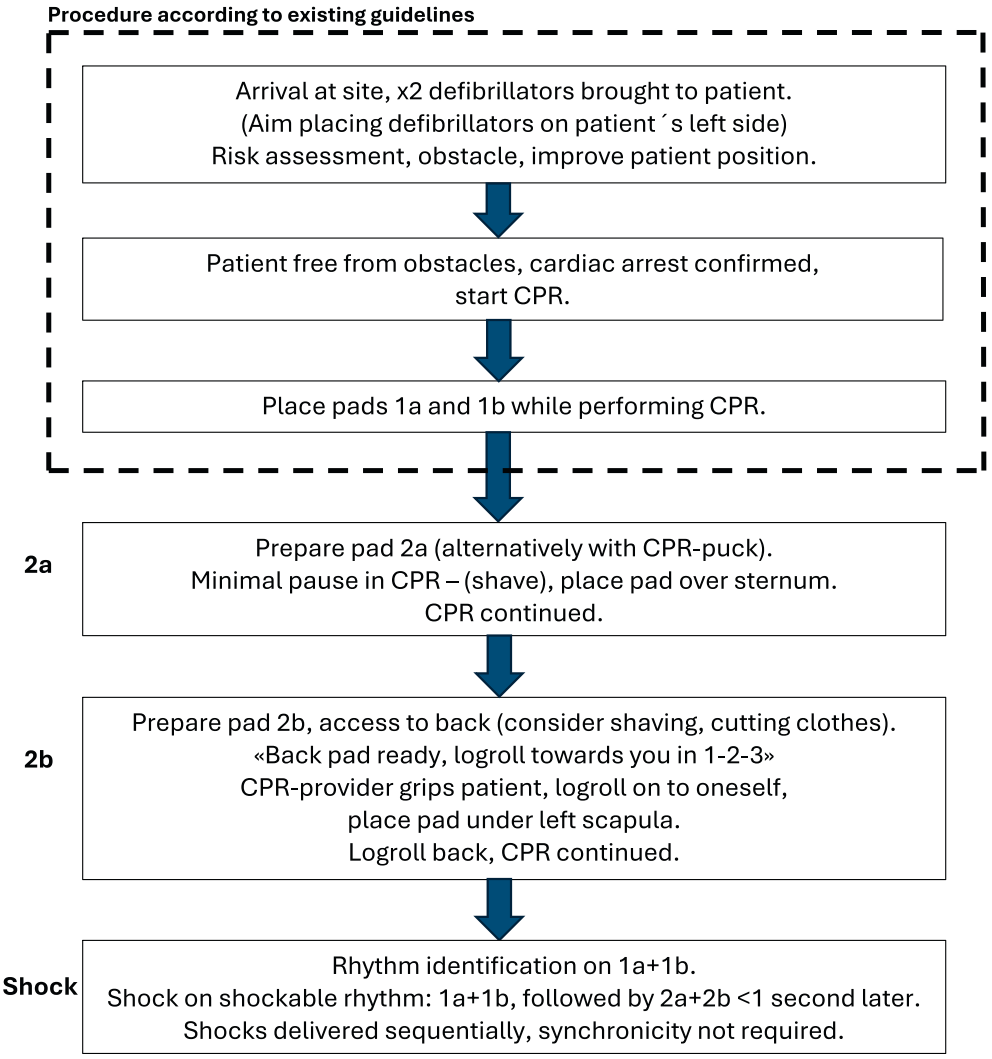

Fig. 2 – Pad placement on live patient model during double sequential external defibrillation procedure.

Results

The two scenarios were repeated 108 times in both patient categories, hence 216 scenarios were performed. Mean time to CPR initiation was 15.0 seconds (s) in patient A, and 17.4 s in patient B. Mean time from the teams entered the room to two pads were attached, was 24.6 ± 3, s for patient A, and 27.4 ± 3.7 s for patients B. Mean time from teams entered the room to four pads were attached, was 38.3 ± 7.0 s for patient A, and 41.3 ± 7.4 s for patient B. The mean difference in time needed for standard pad placement versus DSED was 13.7 ± 4.8 s for patient A, and 13.9 ± 4.6 s for patient B (Fig. 4a). There was no significant difference between the time needed for patient A and B ($p = 0.725$) (Fig. 4b). There were no missing data.

Discussion

This study demonstrates that time needed to place four versus two pads during CPR in a live patient simulation resulted in a very small prolongation of CPR prior to defibrillation. Further, there was no significant difference in necessary time in an overweight compared to a normal weight patient. To our knowledge, there are no studies that describe the time needed to establish standard defibrillation versus DSED treatment. Currently, DSED is used for refractory VF, where the procedure is established after three failed defibrillation attempts. Our findings support that DSED can be provided as an initial treatment, given appropriate training. If used, it is of paramount importance that DSED is established as efficiently as possible, without unnecessary delay in patient treatment to avoid decrease in chance of survival.[22] Short pauses (2–35 s) in CPR is shown to no impact arterial blood pressure recovery after the pause.[23]

The times registered was measured in a simulated scenario. The necessary difference in time for DSED versus standard treatment accounts for a small part of the total time from dispatch of ambulance personnel to either one or two defibrillators are readied at the patient. This will decrease the relative difference in time between the two procedures. According to guidelines, shocks should be delivered every two minutes in shockable rhythms,[24] while every third minute is used in Norwegian guidelines.[20] Hasegawa et al.[4] found that more than 50% of patients needed more than two defibrillations. If DSED can terminate the malignant arrhythmia earlier than standard treatment, ROSC may be achieved 2–3 min earlier, or more, and we argue that this potential benefit justifies a minimal increase in hands-off time.

Fig. 3 – Procedure for double sequential external defibrillation. CPR indicates cardiopulmonary resuscitation.

The study also demonstrates that DSED is feasible by a two-member team, without significant time difference establishing DSED in an overweight patient. If this is true also in real life events, remains unknown, but will be assessed in a planned clinical trial at our study site. Challenges like heavy clothing, on-site obstacles, or environmental factors such as rain or low temperatures will likely have an impact. The difference in chest compression fraction (CCF) was not measured in this study. However, previous studies have shown no difference in CCF between DSED and standard procedure, albeit in refractory fibrillation. CCF will be measured in the planned clinical trial. Correct lifting technique is also important for procedure efficiency.

Limitations

This study is not without limitations. First, this was a single centre study. Second, the scenario was designed to find the time difference between two procedures, and therefore no realistic challenges that may arise in a prehospital setting were included. Third, the study was indoors, and actual CPR was not performed. However, the study also has strengths; it was conducted over two days with different participants, and mixed teams on both patient categories. Further, the procedure was performed multiple times. In addition, the same two participants timed the procedures both days, which may limit registration bias.

Conclusion

The study demonstrates that the necessary time to establish DSED versus standard defibrillation pad placement was short in both normal and overweight patients. This may support clinical studies on DSED as initial treatment for OHCA patients and not exclusively for refractory ventricular fibrillation, without risk of significant increase in time to first defibrillation.

Availability of data and materials

The dataset used may be available from the corresponding author upon reasonable request.

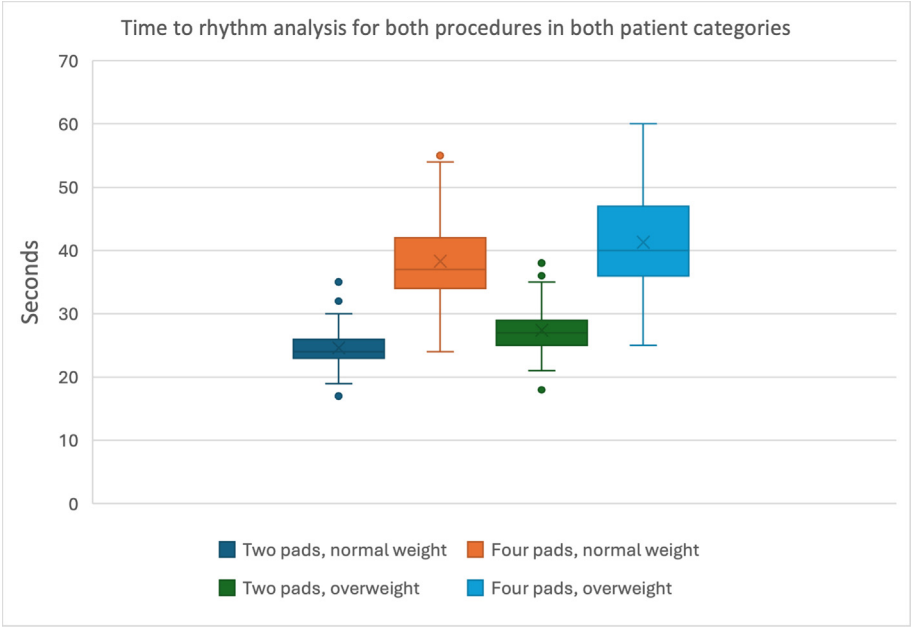

Fig. 4a – Time needed to place two versus four pads for normal and overweight patient.

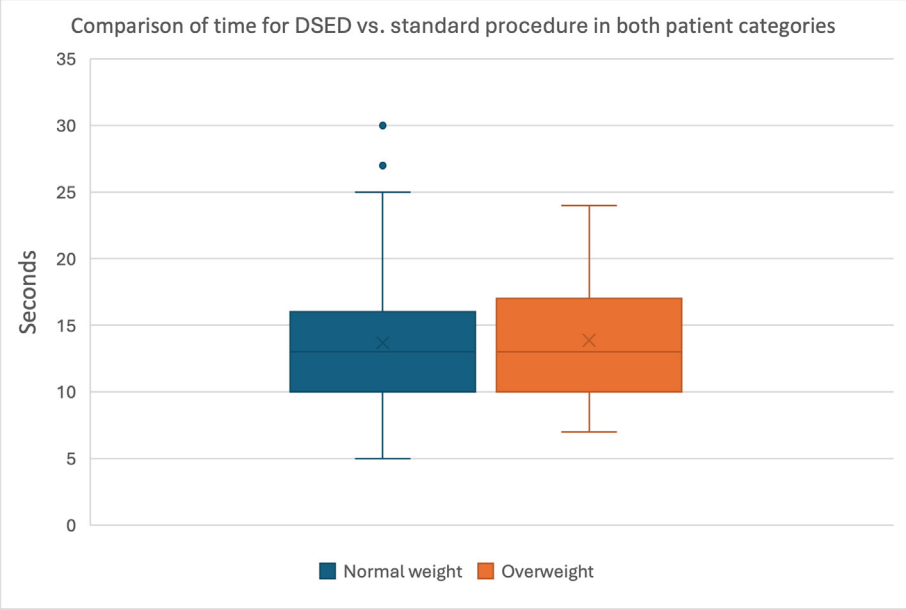

Fig. 4b – Difference in mean time between the two procedures performed on normal weight and overweight patient.

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CRediT authorship contribution statement

Vegard Nordviste: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Marius Rehn:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – review & editing. **Andreas Jørstad Krüger:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – review & editing. **Jostein Rødseth Brede:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: 'The authors declare that they have no competing interest. VN is employed at the Norwegian Air Ambulance Foundation. JRB is partly employed at the Norwegian Air Ambulance Foundation for research purposes and MR and AJK have received funding from the Norwegian Air Ambulance Foundation for research purposes.'.

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