Resuscitation 66 (2005) 171–174

RESUSCITATION

www.elsevier.com/locate/resuscitation

Decreasing the time to defibrillation: A comparative study of defibrillator electrode designs☆,☆☆

Bruce D. Adams [a,b,*], David M. Easty [a], Elaine Stuffel [a], Irma Hartman [a]

[a] *Department of Emergency Medicine, Brooke Army Medical Center, Fort Sam Houston, TX 78234, USA*
[b] *Medical College of Georgia, USA*

Received 17 November 2004; received in revised form 26 January 2005; accepted 26 January 2005

Abstract

Introduction: Time to defibrillation (T_{defib}) is the most important modifiable factor affecting survival from cardiac arrest. Mortality increases by approximately 7–10% for each minute of defibrillation delay. The purpose of this study was to determine whether defibrillator electrode design complexity affects T_{defib}.
Methods: This was a randomized sequential design study utilizing a standardized ventricular fibrillation cardiac arrest model for CPR mannequins. We evaluated two common types of defibrillator electrode models: a single connector design and a double connector design that requires an adaptor. We compared the time required by cardiac arrest team leaders to apply the two types of defibrillator electrodes to a manikin, connect them to a defibrillator, and then deliver a first defibrillatory shock. The primary outcome was time to defibrillation. The secondary outcome was difficulty of application as perceived by the physician participants on a 10 cm visual analog scale.
Results: Thirty-two residents performed a sequential assessment of both electrodes. The average T_{defib} for the double connector model was 42.9 s longer than that of the single connector model (87.5 s versus 44.6 s, $p < 0.001$). As evaluated by the study participants, the single connector model was significantly easier to apply then the double connector model (1.3 cm versus 4.4 cm, $p < 0.001$).
Conclusion: The single connector defibrillator electrode design was associated with a significantly shorter T_{defib} than the double connector design. It also was judged to be easier to apply in this model. Ergonomic design of defibrillator electrodes can significantly impact time to defibrillation.

Keywords: Cardiopulmonary resuscitation (CPR); Defibrillation; Medical Emergency Team; Megacode training; Utstein template; Ventricular fibrillation

1. Introduction

Time is the most important modifiable factor affecting survival from cardiac arrest [1–3]. International guidelines endorse a goal of 2 min from collapse until defibrillation for in-hospital cardiac arrest [3]. Multiple strategies for improving the Utstein time intervals that comprise the “chain of survival” for in-hospital cardiac resuscitation have been scrutinized, including continuous cardiac monitoring [4], establishing cardiac arrest teams [5], and the in-hospital use of automatic external defibrillators [6,7]. However, only limited research has focused on the ergonomic design of CPR equipment [8–11]. More specifically, the impact of the ergonomic design of defibrillator electrodes on time to defibrillation (T_{defib}) has not been published. The application, the connection, and the activation of defibrillator electrodes are all obligatory links in this chain of survival. Long links produce longer chains. Wasting time during these critical actions will directly delay T_{defib} and ultimately may worsen survival outcomes [1,3,12].

☆ A Spanish translated version of the Abstract and Keywords of this article appears as Appendix at 10.1016/j.resuscitation.2005.01.019.
☆☆ Presented as an oral abstract at the American Heart Association Scientific Sessions, November 2004, New Orleans, LA and also as a poster at the American College of Emergency Physicians Scientific Assembly, October 2004, San Francisco, CA.
* Corresponding author. Tel.: +1 210 916 5429/2422; fax: +1 210 916 2265.
E-mail address: bruce.adams@amedd.army.mil (B.D. Adams).

0300-9572/$ – see front matter © 2005 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.resuscitation.2005.01.019

2. Methods

This was a randomized sequential study designed to compare the T_{defib} for two different types of defibrillator electrode designs. The independent variable was the choice of defibrillator electrode used: a single connector design (QuikCombo, Medtronic Emergency Response Systems, Redmond, Washington) and a double connector design (PadPro 2516, PadPro LLC, Ann Arbor, MI, USA) (see Fig. 1). The primary outcome was T_{defib} (the total time elapsed from beginning of cardiac arrest to the delivery of the first defibrillatory shock). The secondary outcome was the perceived difficulty of application of each defibrillator electrode design as measured on a 10 cm visual analog scale. The institutional review board approved the project.

Internal medicine and emergency medicine resident physicians direct nearly all cardiac arrests at our 450-bed teaching hospital, so these cardiac arrest team leaders were recruited as the study participants. Physician demographics including specialty, level of training, and previous cardiac arrest experience were recorded on a data collection sheet. The physician participants were blinded to the specific purpose of the study; initially being told only that they were partaking in a “CPR study”. Under the scripted direction of two Advanced Cardiac Life Support® trained research nurses using a standardized cardiac arrest model on CPR manikins, the participants were instructed that the monitor was showing ventricular fibrillation and that their task was to defibrillate the simulated patient as quickly as possible. The residents were instructed to first apply the defibrillator electrodes, then to make the connections, and finally to administer a first shock. Four time points were recorded for each trial: T_0 = begin trial; T_1 = time to application of both defibrillator electrodes to the patient; T_2 = the time when all connections completed between electrodes and defibrillator; and T_{final} = the total time to delivery of the first shock. This corresponded to three separate task stages: the application stage = $T_1 - T_0$; the connection stage = $T_2 - T_1$; and the activation stage = $T_2 - T_{final}$. The sum of these three stages comprised our primary outcome of T_{defib}. The participants were also asked to rate the difficulty of application of each defibrillator electrode by placing a single mark on a 10 cm visual analog scale (0 = easy, 10 = difficult).

The Lifepak® 12 defibrillator/monitor (Medtronic Emergency Response Systems, Redmond, Washington) is the standard defibrillator provided for use in all areas of our hospital. The single connector model defibrillator electrode system was specifically developed for the Lifepak 12. A double connector model electrode system is marketed as an alternate defibrillator electrode, but it requires an additional adaptor to be placed in series in order to be used with the Lifepak 12 (see Fig. 1).

Assuming a 20% difference in treatment effect between the two defibrillator electrode models (two-sided, for alpha = 0.05 and beta = 0.2), we calculated the minimum required sample size to be 26 trials for each type of defibrillator electrode. Statistical significance was analyzed using the paired Student’s *t*-test for continuous variables with 95% confidence intervals. Physicians were assigned first one set of electrodes for this standardized ventricular fibrillation cardiac arrest model on CPR manikins, and then performed a subsequent cardiac arrest simulation on the alternate defibrillator electrode. An important potential confounder was that the electrode in the second trial would benefit from the experience gained by the subject resident in the first trial (“learning”). To control this possibility, we randomized the electrodes to the first sequence of testing.

3. Results

Thirty-two residents performed a randomized sequential assessment of both defibrillator electrodes for a total of 64

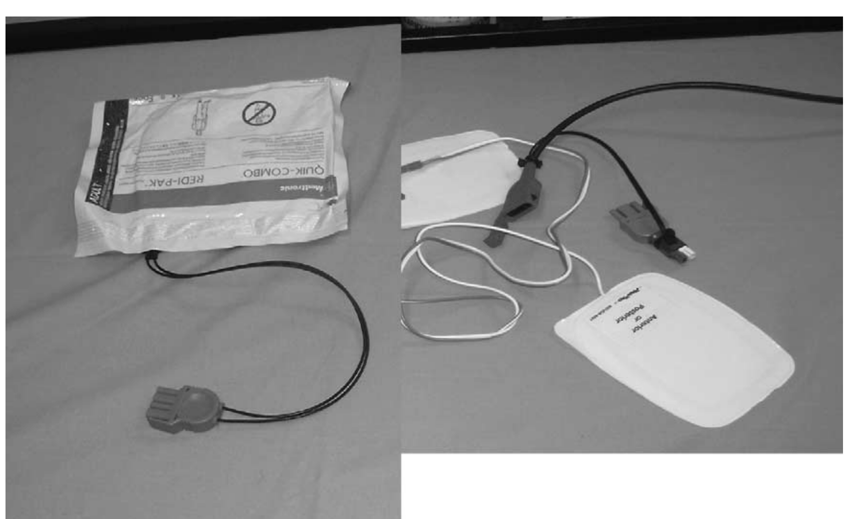

Fig. 1. Comparison of single connector model (left) and double connector model (right) defibrillator electrodes. Note the multiple connections on the double connector model and its adaptor.