Resuscitation 101 (2016) 71–76

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Human Factors Approach to Comparative Usability of Hospital Manual Defibrillators

Richard Fidler[a,c,*], Meshell Johnson[a,b,d]

[a] San Francisco Veterans Affairs Medical Center, University of California, San Francisco, CA 94121, United States
[b] Northern California Institute for Research and Education, University of California, San Francisco, CA 94121, United States
[c] School of Nursing, Departments of Anesthesia and Perioperative Medicine, University of California, San Francisco, CA 94121, United States
[d] Department of Medicine, University of California, San Francisco, CA 94121, United States

ARTICLE INFO

Article history:
Received 26 August 2014
Received in revised form
30 December 2015
Accepted 21 January 2016

Keywords:
Defibrillator
Resuscitation equipment
Simulation
AED
Transcutaneous pacing
Synchronized cardioversion

ABSTRACT

Introduction: Equipment-related issues have recently been cited as a significant contributor to the suboptimal outcomes of resuscitation management. A systematic evaluation of the human-device interface was undertaken to evaluate the intuitive nature of three different defibrillators. Devices tested were the Physio-Control LifePak 15, the Zoll R Series Plus, and the Philips MRx.
Methods: A convenience sample of 73 multidisciplinary health care providers from 5 different hospitals participated in this study. All subjects' performances were evaluated without any training on the devices being studied to assess the intuitiveness of the user interface to perform the functions of delivering an Automated External Defibrillator (AED) shock, a manual defibrillation, pacing to achieve 100% capture, and synchronized cardioversion on a rhythm simulator.
Results: Times to deliver an AED shock were fastest with the Zoll, whereas the Philips had the fastest times to deliver a manual defibrillation. Subjects took the least time to attain 100% capture for pacing with the Physio-Control device. No differences in performance times were seen with synchronized cardioversion among the devices. Human factors issues uncovered during this study included a preference for knobs over soft keys and a desire for clarity in control panel design. This study demonstrated no clearly superior defibrillator, as each of the models exhibited strengths in different areas. When asked their defibrillator preference, 67% of subjects chose the Philips.
Conclusions: This comparison of user interfaces of defibrillators in simulated situations allows the assessment of usability that can provide manufacturers and educators with feedback about defibrillator implementation for these critical care devices.

Published by Elsevier Ireland Ltd

Introduction

Each year there are 200,000 to 300,000 in-hospital cardiac arrests in the United States.[1,2] Despite being surrounded by technology aimed at preserving and restoring life, the survival from in-hospital cardiac arrest remains abysmal with 22% surviving, and only 28% of those survivors being neurologically intact at discharge.[3] Researchers have also described systems deficiencies as a significant component of suboptimal performance in resuscitation events, with 19% of these errors related to accurately delivering shocks.[4,5] One component of a successful resuscitation is the ability to render immediate electrical therapy correctly. It is essential that staff be trained to use the defibrillators, and hospital defibrillators should have an easy-to-use interface. Very little data has been published on defibrillator usability. The aims of this study were to compare the usability of three popular manual defibrillators with AED capability to[1]: determine differences in usability of these defibrillators by measuring time performance for AED shock, manual defibrillation, transcutaneous pacing, and synchronized cardioversion;[2] uncover strengths and weaknesses of each of the defibrillators; and[3] determine whether a clinician preference exists among the devices. Ultimately, the goal is to identify potential user-interface designs that will optimize use and minimize adverse patient outcomes.

* Corresponding author at: San Francisco Veterans Affairs Medical Center, Departments of Anesthesia and Perioperative Medicine, 4150 Clement Street, San Francisco, CA 94121, United States.
E-mail address: richard.fidler@ucsf.edu (R. Fidler).

http://dx.doi.org/10.1016/j.resuscitation.2016.01.029
0300-9572/Published by Elsevier Ireland Ltd

Methods

Study design

This was a prospective observational human factors study using a convenience sample across five hospitals in the Veterans Health Administration System in Northern California (VISN 21). Approval to conduct this study was obtained from both the UCSF Committee on Human Research and the VA Clinical Research Office at the San Francisco VA Medical Center. Staff were sampled in patient care areas requiring ACLS certification such as the Emergency Departments, Intensive Care Units, Telemetry/Med/Surg Units, and Post-Anesthesia Care Units/Operating Rooms.

Equipment used

The defibrillators studied were the Zoll (R Series Plus Monitor Defibrillator, Zoll, Chelmsford, MA), Physio-Control (LIFEPAK 15 Monitor/Defibrillator, Physio-Control, Redmond, WA) and Philips (Heartstart MRx Defibrillator/Monitor, Koninklijke Philips N.V., Amsterdam). Each company loaned defibrillators for the study. The Symbio CS1201 rhythm simulators (Symbio Corporation, Beaverton, OR) were employed to simulate rhythms in scenarios that required electrical intervention. GoPro HD® head cameras (GoPro, Inc., San Mateo, CA) with head straps were used to record exercises when only one observer was present.

Subjects

Participating health care professionals were required to have current ACLS certification. Participation was voluntary and performance data were not shared with supervisors. Subjects were informed that they would receive no education or training in the use of any of the devices, since this study was designed to assess intuitiveness, not skill acquisition or knowledge retention. Subjects were instructed that they would perform AED utilization, manual defibrillation, synchronized cardioversion and transcutaneous pacing on all devices.

Procedure

Each subject was brought into a private room with all three defibrillators on separate tables, all at the same height (Fig. 1). The defibrillators were identically aligned in the room for each subject. Subjects were instructed to choose any device to begin and permitted to choose the order in which they would evaluate each defibrillator. Each defibrillator was connected to a Symbio CS1201 rhythm simulator. To evaluate each defibrillator with a repeatable, structured approach, clinical vignettes and tasks were verbally given to each subject as follows:

1. To evaluate each device in AED mode, the subject was told that a patient was down on the floor in the lobby; the patient was connected to the defibrillator and chest compressions were ongoing. The subjects were then prompted with "Please turn on the defibrillator and, if indicated, deliver a shock using AED mode."
2. To evaluate ease of switching to manual mode and delivering a manual defibrillation, the first vignette was extended, to include that the patient had been resuscitated, and during transport to the Emergency Department, developed ventricular tachycardia at 180 beat min^{-1}. The subjects were prompted with "Please deliver a 200 J manual defibrillation NOW."
3. To assess transcutaneous pacing, the prior case was extended to describe that the patient had developed complete heart block, unresponsive to atropine, and was unstable with blood pressure 70/30 mmHg and heart rate of 30 beat min^{-1}. Subjects were prompted to "Please pace this patient at a rate of 80 beat min^{-1} and announce when you have obtained 100% capture."
4. A new patient vignette was used for evaluating synchronized cardioversion. A patient developed new onset atrial flutter and chest pain. The subjects were instructed, "You will need to deliver a 75 J synchronized cardioversion immediately."

Time to task completion and accuracy of performance were confirmed by two observers or verification of performance parameters by video review of Point-of-View GoPro® HD cameras on the subject's forehead. One study investigator (R.F.) was present for all timing and performance measurements to ensure that the study protocols were carried out identically at all sites. Participants completed all four tasks on one device before randomly selecting the subsequent devices. Vignettes were given to the participants in the same order for each device. Upon completion of all tasks, subjects were asked (1) demographics including gender, age, position and department affiliation; (2) previous device experience; (3) overall defibrillator preference and reason; (4) general comments on usability of the devices tested. After opinions were recorded, performance times were reviewed with the subjects.

Data analysis

Questionnaire data and comments were coded and grouped into common themes. Mean times for completion of each task were calculated and reported + SEM. Analysis of variance (ANOVA) with Bonferroni correction was used for time performances to determine significance, defined as $p < 0.05$. Assessments for inter-machine learning were calculated using repeated measure regression analysis with ANOVA adjusting for subject/machine and machine/rank order interactions.

Results

Subjects

There were 73 subjects from 5 VA hospitals who participated in a structured, human factors evaluation of intuitiveness of three defibrillators, resulting in 219 total evaluations. There were more women participants than men (63% vs. 37%), and there were more RN than MD participants (82% vs. 18%). All study subjects held current (within 2 years) ACLS certification (Table 1).

Table 1
Subject demographics.

Median age in years (range)	42 + 19 yrs (23–72 years)
Women	46 (63%)
Men	27 (37%)
Occupation	
RN	60 (82%)
MD	13 (18%)
Work environment	
ICU	15 (21%)
ED	17 (23%)
Anesthesia	10 (14%)
PACU	9 (12%)
Telemetry	13 (18%)
Medical/surgical care	9 (12%)
VA Hospital	
Fresno	12
Palo Alto	6
Reno	12
Sacramento	13
San Francisco	30