Supplementary Online Content


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This supplementary material has been provided by the authors to give readers additional information about their work.
eMethods. Supplemental Methods

Study Design

Video-Based Orientation

All participants viewed a brief 5 minute standardized video-based orientation to American Heart Association (AHA) guidelines for high quality cardiopulmonary resuscitation (CPR) and the research study. This video included a review of guideline compliant chest compression (CC) technique (e.g. chest compression depth >50mm, rate 100-120/min, chest compression fraction >80%) and demonstration of good and poor technique. This was followed by a description of the functionality of the visual feedback (VisF) device, and review of the simulator function and clinical environment. After the orientation, all participants were given the opportunity orient themselves to the simulator by feeling pulses, and auscultating heart sounds and breath sounds.

Just-in-Time (JIT) CPR Visual Feedback Training before CPA

This video included: (a) review of CC technique and AHA guidelines; (b) orientation to CPR VisF device and proper use; (c) expert modeling of CC using the VisF device; and (d) instruction for team members to sequentially provide 2 minutes of CC each with VisF.

Randomization

Randomization packages were prepared at a central study site by a research coordinator. Recruitment packages at each site contained 4 separate and sealed envelopes (one envelope for each study arm) with study arm assignments and random unique identifier codes for the individual participants within the envelopes. One envelope was pulled randomly from the recruitment package for each team on the day of the study. To ensure randomization by blocks of 4, all envelopes from each recruitment package were utilized before opening the next recruitment package.

Standardized Simulated CPA Scenario, Confederate Actors, and the Simulation Environment

The Laerdal SimJunior™ used for this study is capable of reproducing physical and physiological responses to medical interventions. This simulator is connected to a monitor where vital signs (heart rhythm, respiratory rate, oxygen saturation, blood pressure, temperature) are displayed. Through a computer interface, an operator can run pre-programmed scenarios where vital signs on the monitor and physical findings on the simulator change in real time. The mannequin is capable of producing heart sounds, breath sounds and palpable pulses. The simulator can be bag-mask ventilated, the trachea intubated and the heart defibrillated.

The team leader role was pre-assigned prior to the initiation of the scenario. The team leader was tasked with leading the team and providing medical oversight, and told specifically not to provide chest compressions. The two other team members recruited for the study did not have specific pre-assigned roles, but the design of the scenario was to allow them to focus on providing chest compressions during the simulated cardiac arrest. The two actors (e.g. confederates) from the research team were trained and instructed to stay in their roles as medication nurse and respiratory therapist for the duration of the scenario, and specifically scripted not to provide chest compressions or offer suggestions for medical management. All 3 participants were informed during the standardized orientation video that the medication nurse and respiratory therapist (e.g. actors) were not permitted to perform chest compressions. Team members were permitted to switch chest compressors during the scenario at their discretion, under the guidance of their team leader.

Confederate actors were all trained in a highly standardized fashion, which included: (a) review of a presentation describing actor roles; (b) viewing of a video depicting expert modeled actor behaviors during the cardiac arrest scenario and (c) use of a cue card during the simulated CPA to help guide appropriate behavior. Actors were instructed to: (a) perform tasks as directed by team leader; (b) provide information when cued or asked directly; and (c) introduce distracters only as described in their scripted roles. During a pre-study run-in phase, all recruitment sites were required to conduct and transmit a videotape of a pilot session of the cardiac arrest scenario to ensure appropriate conduct of the scenario and actors before the site was permitted to conduct and submit data from their site. By prospective design, videos and data collected during the pilot run-in phase was not included for analysis in the main study. Subjects recruited during this phase were not eligible for inclusion in the main study. During the conduct of the study, investigators at each site continued to videotape all cardiac arrest scenarios, with the videotapes reviewed (by the research team at a centralized site) for compliance of actors/confederates with the training expectations, violation of protocol and complete acquisition of study data without technological flaw. It was

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anticipated that approximately 15% of scenarios would have technical flaws that would prevent inclusion in the final analysis.

Study Participants

Each team was comprised of five people, including two actors playing the scripted roles of respiratory therapist and medication nurse. Inclusion criteria for research subject team members and team leaders are described below.

**Team Members – Inclusion Criteria:**

- Pediatric healthcare providers: such as nurses, nurse practitioners, medical students, and residents (pediatric, emergency medicine, anesthesia, family medicine)
- No prior experience with CPR feedback devices
- Current American Heart Association Basic Life Support (BLS), Pediatric Advanced Life Support (PALS) or Advanced Cardiac Life Support (ACLS) certification within the past two years (ie. demonstrated competency in CPR skills)

**Team Leader – Inclusion Criteria:**

- Residents (Year 2, 3 or 4) in pediatrics, family medicine, anesthesia, or emergency medicine training programs
- Fellows in pediatric emergency medicine, pediatric critical care or pediatric anesthesia subspecialty training programs
- No prior experience with CPR feedback devices
- Current American Heart Association PALS certification in the past two years

**Team Member and Leader – Exclusion Criteria:**

- Previous experience using, teaching with, or learning with a CPR feedback device
- No current American Heart Association BLS, PALS or ACLS certification within the past two years
# eTable 1 – Recruitment Sites

<table>
<thead>
<tr>
<th>Recruitment Site</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta Children’s Hospital</td>
<td>Calgary, Canada</td>
</tr>
<tr>
<td>Hasbro Children’s Hospital</td>
<td>Providence, USA</td>
</tr>
<tr>
<td>Stollery Children’s Hospital</td>
<td>Edmonton, Canada</td>
</tr>
<tr>
<td>Children’s of Alabama</td>
<td>Birmingham, USA</td>
</tr>
<tr>
<td>Montreal Children’s Hospital</td>
<td>Montreal, Canada</td>
</tr>
<tr>
<td>Ann &amp; Robert H. Lurie Children’s Hospital of Chicago</td>
<td>Chicago, USA</td>
</tr>
<tr>
<td>Children’s Medical Center</td>
<td>Dallas, USA</td>
</tr>
<tr>
<td>Johns Hopkins Children’s Hospital</td>
<td>Baltimore, USA</td>
</tr>
<tr>
<td>Columbia University College of Physicians and Surgeons</td>
<td>New York, USA</td>
</tr>
<tr>
<td>Bristol Royal Hospital for Children</td>
<td>Bristol, United Kingdom</td>
</tr>
</tbody>
</table>
**eTable 2 – Pediatric Simulated Cardiopulmonary Arrest Scenario**

PULSELESS ELECTRICAL ACTIVITY (PEA) $\rightarrow$ VENTRICULAR FIBRILLATION (VFIB) $\rightarrow$
RETURN OF SPONTANEOUS CIRCULATION (ROSC)

**Learning/Research Objectives**

- Initial assessment and management of a patient in cardiac arrest
  - Circulation, Airway, Breathing
- Recognize Rhythm and Algorithm: Pulseless Electrical Activity (PEA) / Ventricular Fibrillation
- Deliver high quality CPR as treatment for pulseless cardiac arrhythmias
  - Switch chest compressors q2min
  - Minimize interruptions in CPR (optimize Chest Compression Fraction)
  - Record quality of chest compressions (CC depth, CC rate, CC Fraction)
- Assess the management of PEA and Ventricular Fibrillation
  - Appropriate epinephrine administration – dose, timing, concentration, route
  - Discussion of potential etiologies for PEA
    - Hypovolemia
    - Hypoxia or ventilation problems
    - Hydrogen ion (acidosis)
    - Hypo/hyperkalemia
    - Toxins
    - Tamponade, cardiac
    - Tension pneumothorax
    - Thrombosis (coronary or PE)
    - Trauma (hypovolemia, increased ICP)
  - Appropriate defibrillation – dose, non-synchronized, timing, safe defibrillation

**Script for Simulation Facilitator**

All Participants should be familiar with the simulator

Orient participants to the environment and location of equipment (standardized for all sites)
(i.e. expectations are to apply leads and pads, turn on and use equipment oxygen, defibrillators, etc.)

Begin with the manikin under a sheet
(explain to participants removing the sheet will represent the patient arriving)

Start video recording

Please read this:
*You are in the Pediatric Emergency Department and just received a rescue call. They are transporting a 5 year old male, found unresponsive at the scene. On initial assessment, the patient was bradycardic with a heart rate of 20. En route, the patient has subsequently lost his pulse. They have been performing CPR the entire time. They have established an IV, and they were successful in securing an airway, ETA is 2 minutes”*

After 30 seconds start the simulator program, remove the sheet and state:
“The patient has arrived, prehospital personnel have left, there is a functioning IV in the right antecubital fossa.”

Whenever you see a pulse check (without chest compressions) please verbalize:
“There is no palpable pulse”
Whenever you see check of airway and breathing please verbalize:
“There are no spontaneous respirations”

After 12 minutes please state:
“There is now a pulse, we are going to stop the simulation here, thank you.”

Nursing and Respiratory Therapist Confederate roles are described with the scenario.
<table>
<thead>
<tr>
<th>Scenari o Stage</th>
<th>Patient Condition</th>
<th>Simulator Parameter s</th>
<th>Expected Interventions</th>
<th>Cues</th>
<th>Confederate Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEA 6 minutes</td>
<td>History: 5 year old boy, was playing soccer with friends at the park and collapsed—bystander called 911. Upon paramedic arrival, patient unconscious, shallow respiration, weak pulse with HR 20.</td>
<td>Vitals: T 36.5, HR 20, RR 0, Sat N/A, BP N/A.</td>
<td>Airway: Confirm ETT tube placement by auscultation or direct visualization.</td>
<td>Cues: No pulse.</td>
<td>Nurse: You will: -connect the patient to monitors if asked. -simulate drawing up meds, handing meds to the team for administration. -prepare and administer IVF if asked. If asked to perform CPR, you will state that you are the only nurse and need one of the other team members to perform CPR. -You will not offer information about vital signs or change in rhythm, other than confirming no pulse and no respiratory effort. -You will confirm no pulse and no respiratory effort.</td>
</tr>
</tbody>
</table>
| Ventricular Fibrillation 6 minutes | Condition:  
- unconscious, unresponsive, apneic | Vitals |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Exam</td>
<td>T 36.5, HR 0, RR 0, Sat N/A, BP N/A</td>
</tr>
<tr>
<td>Condition</td>
<td>No palpable pulses, Cap refill 8 secs</td>
</tr>
<tr>
<td>Rhythm</td>
<td>V Fibr</td>
</tr>
<tr>
<td>Monitor</td>
<td>PEA</td>
</tr>
<tr>
<td>CNS</td>
<td>unconscious, eyes closed</td>
</tr>
<tr>
<td>CVS</td>
<td>NO PULSES PALPABLE, cap refill 8 secs, mottled</td>
</tr>
<tr>
<td>Resp</td>
<td>no spontaneous respirations</td>
</tr>
<tr>
<td>Airway</td>
<td>Airway secured by EMS Breathing</td>
</tr>
<tr>
<td>Cues:</td>
<td>Child, unresponsive eyes closed</td>
</tr>
<tr>
<td>Nurse:</td>
<td>Do not announce a change in rhythm</td>
</tr>
<tr>
<td>RT:</td>
<td>Do not announce a change in rhythm</td>
</tr>
</tbody>
</table>

- You will not offer information about vital signs or change in rhythm, other than confirming no pulse and no respiratory effort.
- You will confirm no pulse and no spontaneous respiratory effort.

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<table>
<thead>
<tr>
<th><strong>ROSC @ 12min</strong>&lt;br&gt;Palpable pulses</th>
<th><strong>Rhythm</strong> (Sinus 120)</th>
<th>Nurse will acknowledge a change in rhythm and a palpable pulse.</th>
</tr>
</thead>
</table>

Allow participants to manage Scenario for 12 minutes, then announce return of spontaneous circulation (ROSC) and stop the scenario.
eTable 3 – Effect of JIT CPR Training and Visual Feedback on Chest Compression Fraction*  

<table>
<thead>
<tr>
<th>CCF Mean (95% CI)</th>
<th>No JIT (90.8%, 92.5%)</th>
<th>JIT (89.5%, 91.3%)</th>
<th>JIT effect on CCF</th>
<th>JIT mean effect or “Main effect”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Visual Feedback</strong></td>
<td>90.8% (89.2, 92.5%)</td>
<td>89.5% (87.6, 91.3%)</td>
<td>-1.4% (-3.9, 1.2%)</td>
<td>-1.7% (-3.5, 0.1%)</td>
</tr>
<tr>
<td><strong>Visual feedback</strong></td>
<td>91.7% (90.5, 93.0%)</td>
<td>90.5% (89.5, 91.4%)</td>
<td>-2.0% (-4.5, 0.5%)</td>
<td></td>
</tr>
<tr>
<td>Visual feedback effect on CCF</td>
<td>0.9% (-1.6, 3.4%)</td>
<td>0.3% (-2.3, 2.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Feedback mean effect or “Main effect”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviations: Just-in-time (JIT), cardiopulmonary resuscitation (CPR), chest compression fraction (CCF)
Chest compression depth indicated by stack of lights on the left, set at depths of <40 mm (arrow), 40-50mm (infant), 50-70mm (child or adult on a hard surface) and >70mm (child or adult on a soft surface). Chest compression rates are indicated by lights on either side of green trapezoid, set at rates of <100, 100-120, and >120 compressions per minute.
eFigure 2 – Study Flow Diagram

Randomization of team leader and team members into one of four study arms

Standardized video orientation to research study: simulator, clinical environment, role of actors, CPR orientation, CPR guidelines (all participants)

No JIT CPR Training (Arms 1 and 2): Team members practice CPR for 2 minutes each (no training video, no visual feedback)

JIT CPR Training (Arms 3 and 4): Team members watch JIT training video, practice CPR for 2 minutes each with visual feedback

All healthcare teams participate in a simulated pediatric sepsis scenario and debriefing

Arm 1: Simulated pediatric cardiac arrest scenario with no visual feedback

Arm 2: Simulated pediatric cardiac arrest scenario with visual feedback

Arm 3: Simulated pediatric cardiac arrest scenario with no visual feedback

Arm 4: Simulated pediatric cardiac arrest scenario with visual feedback

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