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Review article

The use of high-fidelity manikins for advanced life support training—A systematic review and meta-analysis☆

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ABSTRACT

Objectives: The objective of this study was to evaluate the effectiveness of high versus low fidelity manikins in the context of advanced life support training for improving knowledge, skill performance at course conclusion, skill performance between course conclusion and one year, skill performance at one year, skill performance in actual resuscitations, and patient outcomes.
Methods: A systematic search of Pubmed, Embase and Cochrane databases was conducted through January 31, 2014. We included two-group non-randomized and randomized studies in any language comparing high versus low fidelity manikins for advanced life support training. Reviewers worked in duplicate to extract data on learners, study design, and outcomes. The GRADE (Grades of Recommendation, Assessment, Development and Evaluation) approach was used to evaluate the overall quality of evidence for each outcome.
Results: 3840 papers were identified from the literature search of which 14 were included (13 randomized controlled trials; 1 non-randomized controlled trial). Meta-analysis of studies reporting skill performance at course conclusion demonstrated a moderate benefit for high fidelity manikins when compared with low fidelity manikins [Standardized Mean Difference 0.59; 95% CI 0.13–1.05]. Studies measuring skill performance at one year, skill performance between course conclusion and one year, and knowledge demonstrated no significant benefit for high fidelity manikins.
Conclusion: The use of high fidelity manikins for advanced life support training is associated with moderate benefits for improving skills performance at course conclusion. Future research should define the optimal means of tailoring fidelity to enhance short and long term educational goals and clinical outcomes.

1. Background

Advanced life support courses, such as Pediatric Advanced Life Support (PALS) and Advanced Cardiac Life Support (ACLS), have recently embraced simulation-based education (SBE) with the incorporation of high-fidelity manikins as part of the experiential learning component of these courses.[1–15] The use of high-fidelity manikins allows learners to engage physically with the simulated patient, assess physical findings, make clinical decisions, and can increase realism of interactions with other healthcare

Abbreviations: PALS, pediatric advanced life support; ACLS, advanced cardiac life support; SBE, simulation-based education; SMD, standardized mean difference.

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professionals in a team-based resuscitation environment that closely approximates clinical practice. SBE has been the subject of much research for both adult and pediatric providers, and has demonstrated benefits for improving knowledge, skills, behaviors and patient outcomes.[16]

Recent systematic reviews of the emergency medicine,[17] pediatric[18] and resuscitation education[19] literature have found equally compelling results supporting the use of simulation-based education in comparison with either no intervention or non-simulation educational interventions. Each of these systematic reviews sought to compare the effect of low-fidelity versus high fidelity simulation training, and reported evidence demonstrating small beneficial effects or a trend towards benefit for high fidelity training.[17–19] However, none of these studies focused purely on advanced life support training, and were limited either by a small number of studies, search strategies that were focused on topics other than fidelity, or lack of a quantitative synthesis. We aimed to conduct a systematic review and meta-analysis of the published literature comparing the use of high versus low fidelity manikins for participants undertaking advanced life support training.

2. Methods

This review was planned, conducted and reported in adherence with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards of quality for reporting meta-analyses.[20] The review was conducted as part of the International Liaison Committee on Resuscitation (ILCOR) 2015 evidence evaluation process (available at https://volunteer.heart.org/apps/pico/Pages/default.aspx), but recommendations generated from ILCOR are distinct from the results and discussion of this study (as the search dates were different).

2.1. PICO question

We sought to identify evidence to address the PICO (Patient/population, Intervention, Comparator, Outcome)[21] question: for participants undertaking advanced life support training in an education setting (P), does the use of high-fidelity manikins (I), in comparison to low-fidelity manikins (C), improve knowledge, skill performance at course conclusion, skill performance between course conclusion and one year, skill performance at one year, skill performance in actual resuscitations, and patient outcomes (O)?

2.2. Study eligibility

We included comparative studies published in any language that (1) investigated the use of high fidelity manikins versus low fidelity manikins for training health care providers at any stage of training or practice, including physicians, nurses, paramedics, respiratory therapists, and emergency medical technicians and (2) focused solely on neonatal, pediatric or adult advanced life support training. Studies focusing on individual resuscitation skills (e.g. chest compressions or intubation) or basic life support were not included. We included two-group non-randomized and randomized studies making comparison between advanced life support training with high and low fidelity manikins. All other study types, and studies with no active comparison were excluded.

2.3. Data sources

We searched PubMed, Embase, and Cochrane with the last search date of January 31, 2014. The search sought studies of advanced life support broadly and included the terms “cardiopulmonary resuscitation”, “advanced cardiac life support”, “advanced life support”, “cardiac arrest”, “life support care”, “simulation”, “patient simulation”, “manikin” and “mannequin” amongst others. The complete search strategy is described in the online supplemental material (online appendix).

2.4. Study selection

The titles of all potentially eligible studies were screened for inclusion by two reviewers (A.C., A.L.) with an overall agreement of 98.8%. The abstracts and full texts of articles not excluded by both reviewers after screening of titles were then reviewed to identify articles meeting criteria for inclusion in the present review. Disagreements were resolved by discussion and consensus between the two reviewers. For the purposes of study selection, we defined manikin fidelity as the physical properties of the simulation manikin. High fidelity manikins are “those that provide physical findings, display vital signs, physiologically respond to interventions (via computer interface) and allow for procedures to be performed on them (e.g. bag mask ventilation, intubation, intravenous insertion)”,[18] while low fidelity manikins are “static mannequins that are otherwise limited in these capbilities”.[18]

2.5. Data collection

We extracted data from each study independently and resolved all conflict by discussion to reach consensus. We abstracted information on the study design, clinical topic and nature of intervention, type of high fidelity simulator, participant characteristics, and outcomes type. As per the GRADE methodology, data were abstracted separately for various learning outcomes, including knowledge at course conclusion, skill performance (e.g. clinical performance rated using a checklist in a simulated setting) at course conclusion, skill performance at a time between course conclusion and one year and skill performance at one year. We reviewed each article to capture outcomes in real patients by extracting data for skill performance in actual resuscitations and real patient outcomes. In the case of inconclusive or missing data, the original authors were contacted to obtain missing details.

2.6. Analysis and GRADE approach

We conducted both quantitative and qualitative syntheses of the evidence. Trials reporting the same level of outcome (e.g. skill performance at course conclusion) were compared using a standardized mean difference (SMD) to allow direct comparison of the results.[22] We used random-effects meta-analysis to quantitatively pool results for outcomes with more than one study.[22] In interpreting the clinical significance of our results, we emphasized confidence intervals (CI) in relation to Cohen’s effect size (or SMD) classifications, where SMD >0.8 large; SMD 0.5–0.8 = moderate; SMD 0.2–0.5 = small; and SMD <0.2 = negligible.[23] Data was entered into Review Manager (RevMan5, The Cochrane Collaboration, Oxford, UK) to calculate SMD, 95% confidence intervals and statistical heterogeneity. We quantified between-study inconsistency for analyses with more than three studies using the I^2 statistic,[22] which estimates the percentage of variability not due to chance. I^2 values >50% indicate large inconsistency or heterogeneity. Studies that could not be combined in quantitative synthesis of results were analyzed and summarized in a narrative fashion.

The GRADE (Grades of Recommendation, Assessment, Development and Evaluation) approach was used to evaluate the overall quality of evidence with respect to five different domains of quality[24]: (1) limitation of study design and execution; (2) inconsistency; (3) indirectness; (4) imprecision; and (5) publication bias across all included trials. An evidence profile was created with one row dedicated to each outcome. Rating was conducted by one author (A.L.) and verified by a second author (A.C.). A four-point