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Cost-effective and low-technology options for simulation and training in neonatology

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ABSTRACT

The purpose of this review is to explore low-cost options for simulation and training in neonatology. Numerous cost-effective options exist for simulation and training in neonatology. Lower cost options are available for teaching clinical skills and procedural training in neonatal intubation, chest tube insertion, and pericardiocentesis, among others. Cost-effective, low-cost options for simulation-based education can be developed and shared in order to optimize the neonatal simulation training experience.

Introduction

The use of simulation-based education in medicine has grown exponentially in the last 2 decades, spawning a new industry dedicated to the development and production of new and more technologically advanced simulators. Utilization of simulation for medical training is supported by adult learning theory and an expanding body of research evidence, but the cost for using this technology can be significant. Millions of dollars are spent by hospitals and universities to build state-of-the-art simulation centers and to purchase high-tech equipment and simulators, some costing upward of tens of thousands of dollars. The expense does not end with the equipment purchase, however, as associated costs such as maintenance and personnel must also be considered.

The expense of simulation technology and its application to training may be cost-prohibitive for some centers and training programs. Cost has particular implications for simulation programs in developing countries. But even well-funded training programs and simulation centers have budget constraints and therefore need to practice cost-conscious education. In some instances it may not be necessary to spend extra money on expensive simulators. For example, training staff to give subcutaneous injections using oranges instead of task trainers is certainly less expensive and may be just as effective. In another example utilizing 2 l bottles filled with water to practice chest compressions may be more cost-effective than purchasing a mannequin for the same purpose. One particularly striking example of the effectiveness of low-cost equipment to provide effective education and improve outcomes is the Helping Babies Breathe project, which employs the use of a simple, low-cost mannequin to teach newborn resuscitation in low-resource countries. There is a growing interest in developing low-cost simulators and cost-effective programs to accomplish the goals of delivery of high quality and effective simulation-based education. We review here the current literature on available low-cost and cost effective simulation in neonatology and put forth some potential new models and applications.

Fidelity

When considering simulation technology, it is important to review the terminology, and make the important distinction

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between technology and fidelity. *Technology* refers to the use of computer software and hardware as well as other electronics in simulators. *Fidelity* refers to the degree to which a simulator or simulation approximates the appearance and behavior of the model/situation being simulated.[1] Engineering fidelity describes the replication of the physical attributes of the model or task being simulated,[2] and can refer to either the simulator itself or to the physical environment in which the simulation occurs. For example, a neonatal manikin approximating the size and physical attributes of a real newborn with the ability to replicate pulses, breath sounds and cyanosis has high engineering fidelity. As the degree of engineering fidelity increases, often so do the level of technology and the cost. Meanwhile, psychological fidelity refers to how well the simulator approximates the feel or realism of the task being simulated.[2] A chest tube simulation using Cornish game hens has low physical fidelity but closely replicates the feel of placing a chest tube and has higher psychological fidelity. The optimal type and degree of fidelity depends greatly on the purpose of the simulation, the learning objectives and the prior training or experience level of the learner.

In the literature on simulation, fidelity most often refers to engineering fidelity. *High-fidelity* often refers to manikins that have a high degree of physical fidelity and are also highly technology dependent such as Newborn HAL (Gaumard Scientific, Miami, FL, USA) or SimBaby (Laerdal Medical Corp., Wappinger Falls, NY, USA). High-fidelity simulation (HFS) training has been shown to improve performance in adult and pediatric resuscitation.[2–4] Work comparing HFS to low-fidelity simulation (LFS) has failed to reveal a strong consistent benefit of HFS over LFS.[5–7] Currently there does not appear to be sufficient evidence to determine whether high-fidelity simulation is better than low fidelity simulation. Learners report higher satisfaction with high-fidelity mannequins in this and other studies[8] and there is likely gain from enhanced realism.

Enhancing realism without cost

Achieving buy-in from learners though increased realism of a simulation may translate into improved educational outcomes. Realism may be enhanced, however, without significantly increasing costs of simulation. One strategy to enhance realism is the use of moulage, the art of applying mock pathologic conditions or injuries to a simulator or standardized patient for the purpose of training. Commercial kits that simulate a range of pathophysiology including gastroschisis, omphalocele, myelomeningocele, abdominal distention, subgaleal hemorrhage are available for purchase, but may cost hundreds or thousands of dollars. With a little creativity and some household products, many pathologic conditions can be simulated without significant expense. Recipes for blood, vernix, meconium, and emesis can be found on the internet. Cyanosis and ecchymoses can be recreated with make-up. Expired intravenous, umbilical/central line, airway and suction equipment can be used to "dress-up" a basic, low fidelity manikin.

Realism can also be enhanced by recreating the real-world environment in which the simulation scenario takes place. Rooms can be designed to match the delivery room or bed space in the NICU using the learner's typical equipment, such as a radiant warmer, crib, and a supply/code cart. Resources such as gowns, gloves, towels and blankets can be made available. In-situ simulations enhance realism as learners are provided with the equipment they are accustomed to using in a familiar environment. The incorporation of multi-media can also enhance the realism of a scenario. Computer screens can be used in place of bedside monitors to display vital signs. Powerpoint presentations containing radiologic studies and EKGs can be made available for simulation participants. The inclusion of documentation such as nursing flow sheets or "dummy" charts in the EHR provides participants with necessary information without involving confederates or requiring the instructor to interrupt participation in the simulation to provide additional information. Enhancing realism through careful attention to detail does not need to involve significant cost. It is limited only by the educator's time and creativity.

Clinical skills

Changes to pediatric residency programs in recent years, including the adoption of ACGME mandated duty hour regulations, and reductions in intensive care rotations, have created challenges for educators training the next generation of pediatricians and pediatric subspecialists. Experience gained through direct patient encounters does not ensure adequate training in management of pediatric emergencies and critical care procedural skills.[9,10] Real-world experiences in neonatology training may be supplemented using simulation.

Simulation-based neonatal and obstetrical resuscitation programs such as NeoSim and the Obstetric Emergency Training Program are highly-rated by learners but tend to rely on high-fidelity, technology driven manikins.[11,12] Since 2010, the Neonatal Resuscitation Provider (NRP) course has incorporated training on behavioral skills, and provider courses now contain a mandatory team simulation session with debriefing.[13] To date, the literature is unclear on whether high-fidelity simulators are necessary to achieve the desired educational outcomes such as knowledge acquisition and skill retention in neonatal resuscitation. In a randomized clinical trial by Nimbalkar et al.,[14] undergraduate students who learned neonatal resuscitation using either a low-fidelity Resusci Baby Basic or a high-fidelity SimNewB manikin exhibited equivalent performance on both the written test and the Megacode. Skill retention 3 months after training was equivalent.

Mock code programs provide learners, especially trainees such as residents and fellows, with an opportunity to practice the critical care skills necessary to appropriately manage neonatal emergencies in the delivery room and in the NICU. These programs have become more prevalent as trainee experience with real-life emergencies decreases. Barry et al.[15] assessed delivery room based education using a low fidelity neonatal simulator in the setup of resuscitation equipment