Best Practice & Research Clinical Anaesthesiology 25 (2011) 473–487

Contents lists available at SciVerse ScienceDirect

Best Practice & Research Clinical Anaesthesiology

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

1

High fidelity simulation as a research tool

Keith E. Littlewood, MD *

Assistant Dean for Clinical Skills Education, Vice Chair for Education, Anesthesiology, University of Virginia Health System, University of Virginia, Department of Anesthesiology, PO Box 800862, Medical Simulation Center, UVA Health System, Charlottesville, VA 22908-0862, USA

Keywords:
medical simulation
patient simulation
translational education research
patient safety
in situ simulation
crisis resource management
team performance

Medical simulation has grown explosively over the last decade. Simulation is becoming commonplace in clinical education but can also be used as an investigative clinical tool in its own right. There are thus two arms of simulation in clinical research. The first is investigation of the clinical impact of simulation as an educational tool and the second as an instrument to assess the function of clinical practitioners and systems.

This article reviews the terminology, current practice and current research in simulation. The use of simulation in assessment of the clinical performance of devices, people and systems will then be discussed and some current work in these areas presented. Finally, medical simulation will be discussed within the paradigm of translational research. Early examples of this 'tool-bench to bedside' model will be presented as possible prototypes for future work directed towards patient safety.

High-fidelity medical simulation has come of age in medical education and training. Conceived and first implemented by anaesthesiologists, this educational modality is now being voraciously adopted by a wide variety of specialties and disciplines. The number of simulation centres has grown exponentially over the last two decades and simulation is being integrated into all phases of medical education. It is now, in some cases, a component of credentialing and maintenance of certification. This widespread adoption, however, generally preceded evidence of efficacy. This issue is particularly important considering the extraordinary resources required to implement and sustain robust simulation education programmes in comparison with other educational methods. Simulation education must prove itself, whether compared to traditional curricula or newer, active-learning strategies.

Because the terminology of simulation is evolving and because the reader may have limited familiarity with simulation education, the discussion that follows begins with a review of current

* Tel.: +1 434 924 9509; Fax: +1 434 982 0019.
E-mail address: klittlewood@virginia.edu.

1521-6896/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.bpa.2011.08.001

practice and nomenclature. Two perspectives on the role of simulation in clinical research will then be considered. The first is from the standpoint of the current use of medical simulation as a tool for the development and assessment of clinical management; the second is simulation as the investigational tool of human factors and system performance in health care. This will be followed by consideration of simulation education within the paradigm of translational research. The purpose of this approach is to develop the fundamental research question that faces simulation educators: Can we demonstrate that simulation programmes improve health-care delivery to patients?

Background

Terminology

A generally applicable definition of *simulation* is: "The technique of imitating the behaviour of some situation or process (whether economic, military, mechanical, etc.) by means of a suitably analogous situation or apparatus, esp. for the purpose of study or personnel training".[1] *Fidelity*, in the context of simulation education, refers to the accuracy with which a simulated environment imitates reality. The term is also often applied to devices themselves. This can be confusing. It is important to understand that the fidelity of a device is a qualitative judgement, usually termed as low, medium or high. Even devices termed high fidelity would rarely be confused with a real patient, body part or skin. For example, the highest-fidelity full-body mannequins, complete with physiological modelling software, pulses, breath sounds, heart sounds, electrocardiogram (EKG), and vascular pressure outputs, are still obviously artificial devices with synthetic coverings, bolted joints and unchanging facial expression. Further, a task trainer (see below) may often be considered on its own merits alone, but a full-body simulator is typically used within a larger setting of real or mock medical equipment, actors and/or confederates in some rendition of the health-care setting. The fidelity of the device is thus functionally intertwined with the reality of the setting and the manner in which it is deployed; consideration of the device's fidelity in isolation is often educationally irrelevant.

A distinction is made between task trainers and full-body simulators. *Task trainers* (sometimes called *table top devices* when of such size and function) are devices designed to provide experience in specific skills or situations. Common applications include airway management, central line placement, bronchoscopy and sonography. *Full-body* simulators are electromechanically outfitted, computer-driven mannequins of varying fidelity. They are designed to represent the entire human patient. *Virtual reality* is a computer-generated representation of a physical entity. In medical simulation, this terminology has been applied particularly to simulators such as bronchoscopy, endoscopy and arthroscopy devices in which the procedural screen image is computer generated. *Haptics* generally refers to the sense of touch and related topics of the processing, perceptions and meaning of touch in humans. Within simulation education, haptic is used more narrowly to denote the physical feedback provided by a device. For example, the haptics of a virtual bronchoscope simulator might be the resistance to instrument movement when virtual tissue is contacted, while laparoscopic procedures in a physical or virtual simulator might imitate the elasticity of retracted tissue. Whether computer created or the characteristics of real materials, these physical responses are critical to the fidelity of procedural training. The general use of *immersive environment* describes the creation of a virtual space about a human. In this discussion, however, it will be used to refer to full-scale simulations by physical devices alone or in combination with virtual reality to recreate a health-care setting. *Debriefing* is the reflective post-scenario discussion of key activities, events and principles from the experience. There are a variety of approaches to this educationally critical process, and there is little standardisation across specialties and disciplines. Furthermore, a scenario will never play out exactly the same for any two groups and no two groups have exactly the same interpersonal communications, emotions or points of focus as they work through a debriefing. The intrinsic variability at the level of groups and extrinsic variability at the level of specialty, discipline and programme combine to represent a great challenge to research metrics of the debriefing experience. In the common anaesthesiology debriefing, participants and observers move to a physically separate space with the availability of scenario audiovisual recordings. The facilitator typically helps the group progress through (1) the immediate emotions of the experience to (2) a common understanding of the events of interest and, finally, to (3)