Part Three: Medical Simulation

What Medical Simulation Programs are Available.

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"See one, do one, teach one... just not on my Mom"

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Background: This manuscript is part-three of a three-part series on Medical Simulation. Part-one addressed the "why" of Simulation, namely, why Medical Simulation offers novel opportunities to improve education, continuing-competency, and patient safety. Part-two focused on the "how" of simulation, namely, how to design, implement, and maintain a viable program. Part-three will now cover the "what", namely what the future directions are likely to be, what sort of programs are currently available, and what evidence supports their implementation.

Definitions: Our definition of "Medical Simulation" means any technique, "low-tech" or "high tech", that attempts to realistically recreate clinical situations and allow training with minimum patient risk. In this way it resembles the "war-games" of the military or "flight simulators" of aviation. Medical training has always involved graduated acceptance of decision-making and supervised practice. Equally, examinations have long included actors. As such, medical training has always incorporated a degree of simulation of real practice. What has changed is the explosion of available technology; the principles of adult education, the focus on patient safety, and the expectation of proof via research. Simulation is therefore a huge topic. We hope to offer a concise introduction.

The Future of Simulation

This is an exciting time for Medical Simulation! As we outlined, in part-one of this series, there are many arguments in favour of Simulation, and numerous educators, clinicians and administrators have become strong advocates. A number of centres have subsequently developed sustainable simulation programs- by applying many of the principles that we outlined in part-two. The cutting-edge of simulation now appears to be evidence-based simulation, collaborative simulation and developing the science of simulation. This will be the focus of this third and final manuscript.

Growing Infrastructure

Local simulation initiatives remain very important, but widespread collaborations can now promote the development of national standards, national advocacy, and multi-centre trials- in addition to the straightforward exchange of ideas. To facilitate collaboration, national organizations now exist such as the Society for Simulation in Healthcare (SSIH)[1], the Critical Care Education Network (formerly the Canadian Resuscitation Institute (CRI)[2], and the Society in Europe for Simulation Applied to Medicine (SESAM)[3].

The SSIH hosts the annual "International Meeting on Simulation in Healthcare" and now administers a peer-reviewed journal, called "Simulation in Healthcare". This has significantly raised the expectations for authors to undertake evidence-based simulation research. This is in stark contrast to erstwhile manuscripts that were typically merely descriptive: describing what had been tried and how it had been conceived.

Instead of each simulation centre creating its own scenarios locally, efforts have been made by groups, such as the CRI, to develop

marketable courses. This centralized effort should raise the quality of Simulation as it usually involves an in-depth needs-assessments (e.g. studying what areas ought to be addressed; what are the deficiencies in the current curriculum; what are the needs of learners), taking pains to incorporate principles of adult education and psychology (e.g. encouraging self-directed learning, bilateral exchange of ideas between facilitator and trainee; courses that are easily modifiable based upon feedback), and developing metrics to analyze participant satisfaction. Evidence-based programs now exist. A few of these are outlined in order to provide practical examples of what is possible. What follows is far from exhaustive, but may help those eager to see how they too can provide unique opportunities for education, patient safety, healthcare-worker safety, and meaningful research.

Acute Critical Events Simulation

The Acute Critical Events Simulation (ACES) program was designed by the CRI.[4] ACES originated with the goal of improving patient safety following the identification of recurrent errors during resuscitation. This two day course was designed by faculty from across Canada to aid with the acquisition of knowledge and procedural skills, but especially behaviors and communication. It has been delivered to hundreds of candidates in both urban and regional settings, and successfully modified for MDs, RNs, and RTs.

Evaluations have consistently been very favorable. Analysis of a Likert-scale questionnaire (0 to 5, with 5 representing strongly agree) issued to the first 50 participants found an overall rating of 4.38 (95% CI, 4.12-4.65) in 2002 and 4.44 (95% CI, 4.3-4.59) in 2003. Participants also felt that ACES was very useful, with scores of 4.33 (95% C.I 4.01-4.67) for 2002 and 4.37 (95% C.I 4.19-4.55) for 2003. Comparing evaluations from one year to the next also demonstrated how the course could be easily modified using a needs-assessment beforehand and feedback afterwards.4 ACES is one of the first courses to focus on Crisis Resource Management (CRM) skills and as such offers a unique and important supplement to other excellent life support courses.

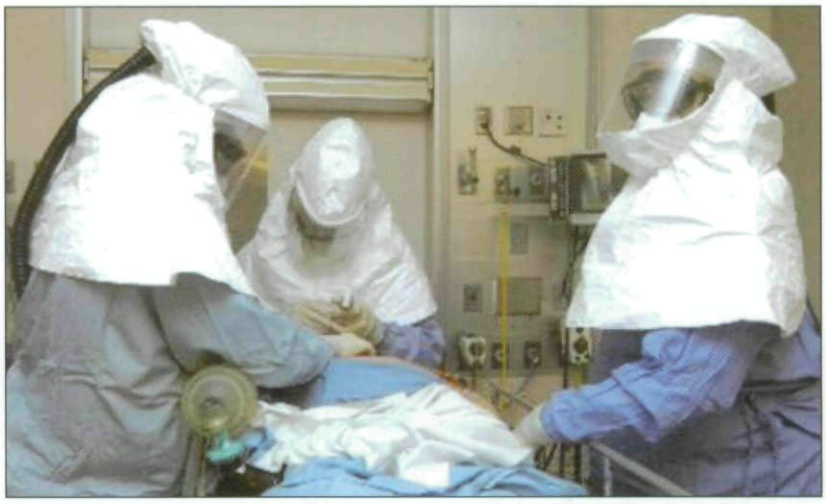

Figure 1: Simulation of Severe Acute Respiratory Distress Syndrome (SARS)
Photo: Dr. Peter Brindley/Dr Randy Wax

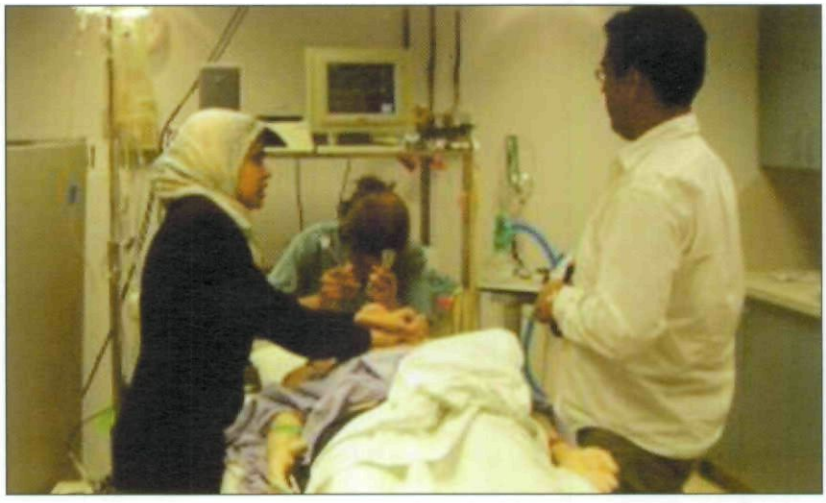

Figure 2: The Acute Critical Events Simulation Course
Photo: CRI Critical Care Education Network

Simulating Telephone Calls

In Canada, large distances and low population density means frequent transport of acutely-ill patients to a single urban centre. A great deal of care is coordinated by telephone, but communication skills are rarely addressed. As such, acute-care teleconference calls have been simulated to help participants develop the "verbal-dexterity" and problem-solving abilities required to care for the acutely-ill. Of note, very little research has been done regarding how best to transition care from one group to another (for example from pre-hospital to the emergency room) or how to safely transport unstable patients across enormous distances. In addition, this strategy provides many of the putative benefits of High-Fidelity Simulation but with minimal cost or logistics. While largely descriptive in nature, qualitative evaluation suggested the exercise was extremely well received, the exercise was deemed realistic,

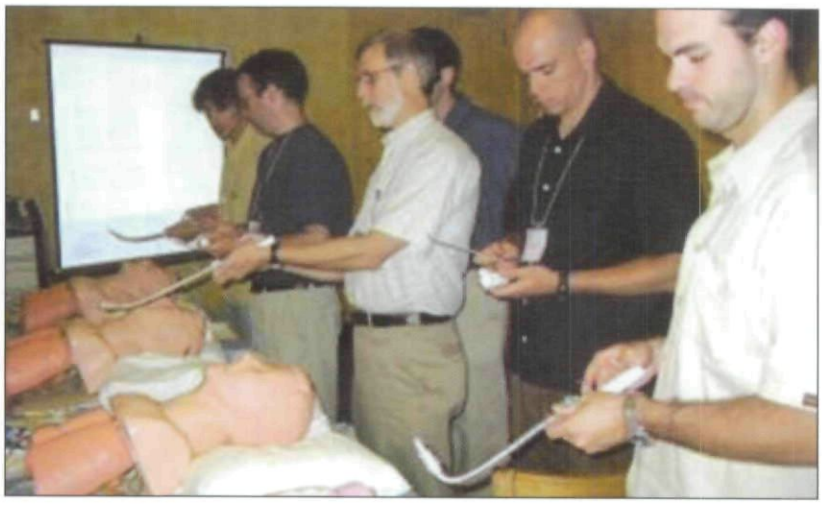

Figure 3: The Acute Critical Events Simulation Course
Photo: CRI Critical Care Education Network

and that mistakes mirrored those in real-practise. All participants felt this strategy was superior to didactic sessions, and complementary to clinical experience. Simulated calls within the same hospital could be performed just as easily, and plans are under way to train both referring and receiving staff using this method.[5]

Simulating Transportation of the Acutely Ill

Wright et al.[6] performed a unique study assessing the feasibility of providing high fidelity simulation in an air ambulance helicopter. Due to cost limitations, the simulation was performed while the helicopter was running at flight idle, rather than in full flight. Despite this limitation, they were able to simulate the noise and vibration present during flight which has profound implications when trying to resuscitate patients. As they described in detail, alarms can be missed and monitors can be blurred, making the helicopter environment particularly difficult to work in.[6]

Twelve residents completed the simulations and all reported an improved awareness of the challenges faced in such environments. All residents agreed that the simulation was educational and should be used for future training.[6] One can easily imagine other difficult scenarios that healthcare workers might find themselves working in, such as in the back of an ambulance, or confined spaces such as elevators. Optimizing transportation remains a poorly studied area, but one with enormous potential.

Simulating Disaster Response

High-fidelity simulation has been used as a method of developing (and refining) complex hospital protocols and disaster plans. These recommendations are often extensively discussed beforehand, but then filed away in policy binders, and rarely practiced. Without testing and refinement, experience suggests they will not be properly applied during the chaos of an evolving crisis. Equally, it is not appropriate to learn through "trial-and-error" when the consequence of "error" could be to worsen an already desperate situation. Furthermore, while patient-safety is finally receiving long overdue attention, similar attention is needed for "healthcare worker safety". Overall, a good example of these challenges, and opportunities, was the outbreak of severe acute respiratory syndrome (SARS) in 2002–3.

Abrahamson, Canzian and Brunet used Simulation to develop and teach the resuscitation of cardiac arrest patients with SARS.[7] This syndrome presented new paradigms in care delivery and, as such, previously entrenched treatment methods were not applicable. For example, hospital workers needed to re-train not to vigorously bag ventilate patients or risk dispersing the SARS virus. Furthermore, workers needed to learn how to put on a personal protective suit (PPS) before they could start.

Intubation of the SARS patient required a PPS in order to mitigate exposure and transmission. However, this seriously hampered communication and procedural dexterity. As Abrahamson et al. note, Simulation "provided insights that had not been considered in earlier phases of development".[7] Expressed another way, if you plan in a boardroom, you will typically come up with boardroom solutions! They had initially timed individuals at 1½ to 2½ minutes to don the suits and designed their protocols around this assumption. However, during simulation, when an entire team had to gown up, the time to don the suits increased dramatically to 3 ½ to 5 ½ minutes. Using results from the actual simulation, they revised their protocol and corrected unanticipated errors in infection control. Impressively, these authors were able to train 275 health care workers within two weeks in this new protocol: a feat that would have been difficult without using Simulation. SARS therefore represents an excellent example of how Simulation offers opportunities for patient safety. These same opportunities exist whether for training in mass casualty, avian flu, or just another "disastrous day" in an overcrowded emergency room.

Use of Simulation in Clinical Trials

Simulation offers unique opportunities to improve the development of clinical trial protocols. Furthermore,

once developed, researchers need to be confident that bedside staff will duplicate these complex protocols precisely. If a protocol is violated it may mean that a patient's data cannot be used. This decreases the statistical power of the study, delays its completion, and wastes resources and money. Experience has also suggested that study outcomes can be significantly different based upon whether the first few patients are included or excluded (likely because of early mistakes adhering to the study protocol). Significantly, this also raises ethical concerns regarding how appropriate it is to perform trials if the first few candidates are exposed to risks. In fact, minimizing harm and striving for equipoise (the belief that benefit and harm are equal for all study participants) is a fundamental requirement for study approval. Overall, Simulation offers a way to protect the rights of study participants, at the same time as optimizing the study's statistical power, and protecting the investigators' scarce resources.

Wright et al.[8] describe using a high fidelity simulator when designing a complex clinical trial in which multiple medications were given at precise times for patients undergoing coronary bypass surgery. As with the SARS resuscitation study, Wright found unanticipated problems with their protocol during simulation, that likely would not have been found otherwise. They were able to train 48 research coordinators and further refine their protocol before any patients were actually subjected to experimentation.[8]

Rapid Response Team Training

Busy medical staff often failure to recognize when inpatients show early clinical deterioration.[9-10] Equally concerning, even when deterioration is recognized, healthcare workers often fail to initiate treatment or access help[10-11] There is little doubt that, for many acute illnesses, outcome is far better with early intervention compared to waiting for full cardiovascular collapse.[9-12] However, there is equally still considerable debate as to the best way to institutionalize rapid response.[10-11] Different jurisdictions have implemented different rapid response teams. These teams differ based upon their composition (e.g. whether an MD or RT is the first responder) and its activation triggers. In Canada, by far the most common model is the Medical Emergency Team (MET).[11]

In theory, MET is activated when hospital inpatients display predetermined aberrant vital signs. MET often consists of a physician, respiratory therapist, and nurse. These professionals must be able to work together in an efficient and collegial way despite varied and stressful situations and disparate training. Equally, despite numerous patients competing for their attention, ward nurses are expected to remember to activate MET in a timely manner. Medical Simulation has therefore been recommended as a way to train all of the personnel involved in these calls.

DeVita et al.[13,14] designed a curriculum utilizing High Fidelity Simulation which focused on developing multidisciplinary team skills

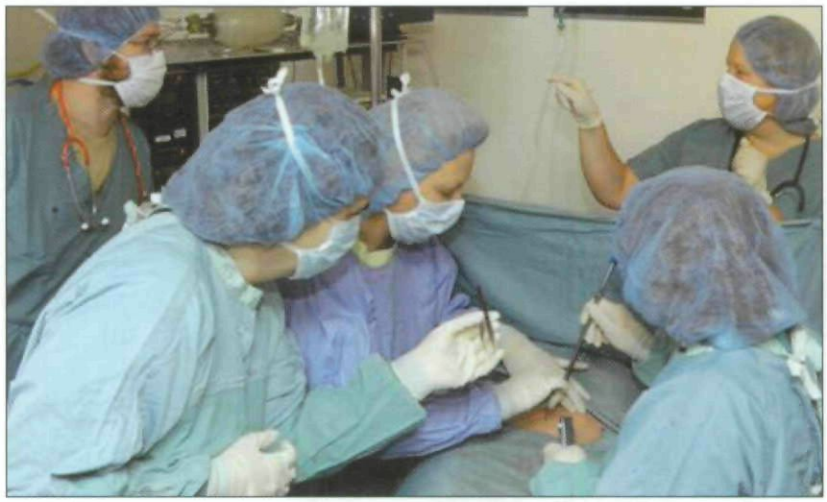

Figure 4: Routine Multi-Disciplinary Operating-Room Simulation

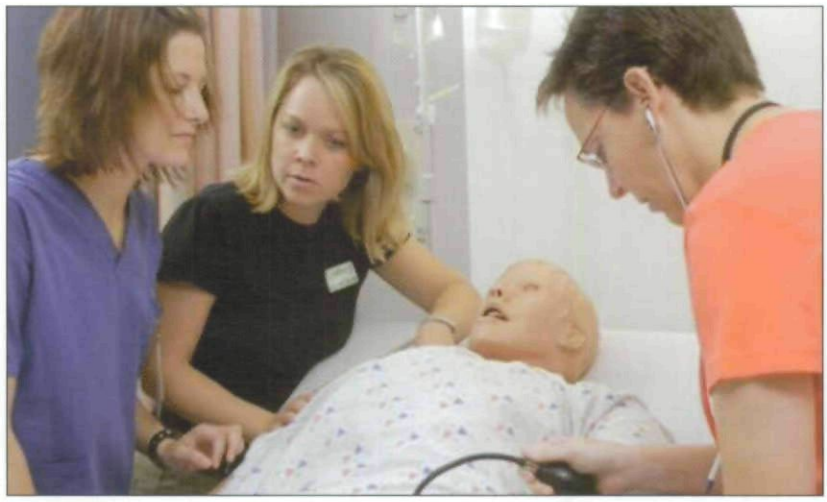

Figure 5: Use of Simulation to Train Multidisciplinary Rapid Response Teams

Figure 6: The Critical Care Education Network (criedunet.ca): A National Collaboration Committed to Increasing Medical Education and Simulation)
Photo: CRI Critical Care Education Network

during medical crises. A total of 138 individuals were trained including 21 respiratory therapists, 48 physicians, and 69 critical care nurses. Following this training, simulated survival (following predetermined criteria for death) increased from 0% to 89%. A similar Medical Outreach Program has been developed by the CRI, and has trained healthcare workers throughout the Province of Ontario (following generous government support).[2] These initiatives suggest that Simulation has enormous potential to help in both triage and resuscitation.

While few would argue with the idea of responding rapidly, the current research has not shown an unequivocal benefit following MET implementation.[9] Simulation research may offer insights as to why not. It may also be invaluable regarding how best to introduce initiatives such as MET, and in understanding the complexities of hospital culture within which the MET must function. Overtime, Simulation may help to finesse rapid response, individualize programs for different hospitals, or even suggest alternative strategies. Simulation has a vital, and currently underutilized, role in this topical debate.

Barriers to Simulation (and how to overcome them)

Dr. David Gaba, a renown champion for Medical Simulation has emphasized that, despite many putative benefits, widespread Simulation is currently the exception in healthcare.[15] Furthermore, due to cost and time constraints, most training programs that do use Simulation expose trainees only a few times per year. For Simulation to be truly accepted and effective, sessions must happen routinely and be "fully integrated into the routine fabric of health care delivery".[15] In fact, the more that Simulation becomes integrated into everyday practice, the greater the support it is likely to garner. In this way participants will increasingly regard Simulation as a normal (non-punitive) part of working in healthcare.

Those already in clinical practice (as opposed to trainees) are currently even less likely to be required to participate in Simulation. This is in stark contrast to other professions such as the airline industry which mandates regular Simulation from the newest employee through to seasoned veterans. As such, senior clinicians need to lead by example. In the current voluntary system, this means requesting simulation experience. Otherwise quality-improvement, and patient-safety, is unlikely to be seen as a system-wide imperative. Equally, for those re-entering clinical practice or changing roles for example from trainee to independent practitioner Simulation offers a way to smooth the transition and offer reassurance.

Numerous comparisons exist between healthcare and other professions that long-ago mandated Simulation. Therefore, it is quite reasonable to mandate Simulation training in healthcare. In fact, increasingly, this appears to be a necessary step towards promoting its acceptance. For example, courses such as Advanced Cardiac Life Support (ACLS®) and Advanced Trauma Life Support (ATLS®) have been mandated for years. Few healthcare workers appear to object to these courses. Similarly, hospitals have been performing mock fire-drills for decades. As such, it seems no different to perform "mock-codes" and "mock traumas", and to do so using the hospital's overhead announcement system. Overall, healthcare's inertia is increasingly difficult to defend. Understanding its causes is another important step forward.

Savoldelli et al.[16] surveyed 154 anesthesiologists to determine barriers to Simulation. Ninety percent of staff physicians reported at least one potential reason. These included "lack of time", "lost income", and "lack of training opportunities". Notably, however, a significant addition barrier for staff physicians was "performance anxiety". Approximately one quarter of respondents reported fearing the judgments of peers and worried about a stressful or intimidating environment in the simulator.[16] Therefore, medical educators must take great care that participants feel safe to learn...and safe to learn from mistakes.

Simulation Research

Lord Kelvin stated that if knowledge could not be expressed "in numbers" then it was "meagre and unsatisfactory". This "Kelvin's Curse" 17 complicates quantitative-research of qualitative-skills such as communication and teamwork. Of note, whether didactic lecturing is beneficial has never been held to similar scrutiny, nor have other professions demanded proof before mandating widespread simulation. The skills addressed through Simulation are not "meagre" or unimportant, as we know that

communication and teamwork to be one of the greatest causes of preventable medical error (see Part One). However, advocates need to accept that traditional research methods and expectations may not apply. Simulation proponents should accept that applications for research grants may compete poorly against traditional research. Strategies therefore include ensuring multidisciplinary input and approaching novel funding agencies, as well as dogged persistence.

Simulation outcomes tend to be qualitative in nature (e.g. is a student able to run a resuscitation more efficiently; can a coworker function better within a multidisciplinary team). These outcomes, while vital, are difficult to express in numerically. Furthermore, following the "scientific method" means accepting that research may or may not ultimately demonstrate a benefit. In short, it may never be conclusively proven that simulators significantly improve clinical outcome.

An intriguing question is that, given all of the potential benefits of Medical Simulation (and the lack of any obvious downside), just what level of proof is needed. Regardless most simulation research does not reach the level expected of traditional research. For example, in a review of over 670 articles covering 34 years, *McGaghie et al.* identified that only 5% of simulation research publications met or exceeded minimum quality standards.[18] Instead, many proponents have focused upon arguments such as the aviation industry mandates regular simulation training for pilots entrusted with passenger's lives, and therefore medical staff, entrusted with a patient's lives, should be no different. Equally if Simulation was instead a pharmaceutical agent, with this much potential to improve outcome and no clear side effects, practitioners would demand widespread access. These common sense arguments are worth making, but cannot be confused with definitive data or proof.

We may indeed be approaching a state where Medical Simulation will become accepted based upon its widespread acceptance and its "face validity". However, it must be appreciated that data is a very powerful ally whenever we are looking to mandate change or redirect funding. Competition for resources is fierce, and without research it will be harder for administrators to secure funds for Simulation, or for educators to demand its widespread application.
In short, Simulation is almost certainly here to stay, but how rapidly accepted or widely integrated it becomes will be influenced upon how well it grows into a scientific discipline. The challenge ahead is clear; whether we will rise to it will represent the next chapter in the evolving story of Medical Simulation.

Summary

The number of simulation programs is increasing rapidly. Furthermore, there is an increased emphasis upon collaboration, incorporating principles of adult education, and demanding simulation research. High quality Medical Simulation now covers the gamut from programs designed to improve acute resuscitation and triage, to improving communication, to improving pandemic planning, and improving clinical trials. There is a need for higher quality evidence-based research if Medical Simulation is to reach its potential. However, significant research challenges have yet to be systematically addressed. Obstacles remain but the opportunities are simply too great not to persevere.

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