

Simulation for Team Crisis Management Training in Critical Care Medicine – Where Have We Been, Where Are We Now and Where Are We Going?

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It has been over a decade since the first articles appeared in the literature raising awareness of the potential value of manikin based simulation with experiential learning for teaching crisis management. Inspired by successful endeavours in the aviation industry, the Stanford University Department of Anesthesia course – Anesthesia Crisis Resource Management (ACRM) was developed analogous to the Crew (cockpit) Resource Management (CRM) course¹. Courses such as this have subsequently been designed for practitioners of a range of specialities who share a common need to improve the crisis management skills of their craft group members. In this article the literature pertaining to team crisis management training in critical care will be reviewed with a commentary on the past, present and possible future of this education method. The authors experience with developing an Intensive Care CRM course will be used as a case study.

Flight simulation is an established component of aviation training, instilling in crew members appropriate, automatic responses to system failures and emergencies. International standards have now been agreed for flight simulators. This important industry is the culmination of over seventy years of work, and tens of billions of dollars investment, by enthusiastic and foresighted individuals².

In the early 1900's a range of new aircraft prototypes were prepared as ground-based trainers which were essentially aircraft tethered in the air by structures such as overhead gantries or mounted on a universal joint in exposed positions. Such devices aimed to expose airmen to the workings of aeroplanes in a risk-free environment as well as assess aptitude of aspiring aviators².

Edwin Link of New York has been called the "Father of Simulation". In the late 1920's he developed the Link (pneumatic) trainer. This device was among a series of new generation trainers that replaced human operators of the trainers with artificial (mechanical or electrical) actuators. Over the subsequent decades he was behind the production of a series of increasingly sophisticated simulators that paralleled advances in electronic technology and the development of analogue then digital computers and the incorporation of increasingly sophisticated motion and visual simulation systems^{2, 3}. In the 1970's a series of organisations, such as the International Airline Flight Simulator Technical Association (IAFSTA), the International Air Transport Association (IATA) and the US Federal Aviation Administration (FAA), can be credited with stream lining simulation culminating in the development of international standards².

Crew Resource Management (CRM) Training in the USA dates back to a workshop, Resource Management on the Flightdeck, sponsored by the National Aeronautics and Space Administration (NASA) in 1979, as a consequence of their research into causes of air transport accidents, particularly failures of interpersonal communication, decision making and leadership⁴. The first comprehensive US CRM program was initiated by United Airlines in 1981. Early courses were psychologically focussed with emphasis on psychological testing and profiling and teaching general managerial concepts such as leadership. Subsequent courses increased the emphasis on group dynamics embracing concepts such as team building, briefing strategies, situation awareness and stress management. Integration with technical training as well as involvement of other groups within airlines such as flight attendants ensued. Most recently an increased focus on

error management and human factors training has occurred, instilling that error is an inevitable result of the natural limitations of human performance and the function of complex systems^{4,5}.

In 1992 David Gaba and colleagues at Stanford University reported on their ACRM course in the *Aviation Space and Environmental Medicine Journal*. They reflected that "anesthesiologists do not typically receive formal training in crisis management although they are called upon to manage life-threatening crises at a moment's notice". Their course included didactic instruction in dynamic decision-making, human performance issues in anesthesia and the principles of anesthesia crisis resource management. Specifically there was a familiarisation with the host institutions' operating rooms and the simulation environment followed by a simulator session coupled with a debriefing, utilising videotape segments of individual's performance. The course was rated highly by participants and the authors concluded that ACRM training should become a regular part of the initial and continuing education of anesthesiologists¹.

In 2003, the Emergency Medicine Crisis Resource Management (EMCRM), a simulation-based crisis management course for emergency medicine residents was described by the Stanford University Group. The course was created using their ACRM template, that had evolved to include a didactic session on principles of human error and crisis management followed by participation in simulated emergency department crisis scenarios (utilising computer-enhanced manikin simulators with standardised cases) and instructor facilitated debriefs⁶.

The reporting of programs designed for a range of craft groups is continuing to occur. Successful simulation-based, team crisis management training courses have been described for Paediatric crisis management⁷, Obstetric Crises⁸, Medical Emergency Response teams⁹, Trauma teams¹⁰ as well as for Radiology¹¹, Hyperbaric units and Medical Administrators. Medical simulation enthusiasts are now spread across the world with other published experiences from groups as geographically distinct as the Harvard University Group (Boston, USA), University of Ottawa (Ottawa, USA), Sunnybrook Health Science Centre (Toronto, Canada), Bristol Royal Infirmary (Bristol, UK), Israel Centre (Tel Hashomer, Israel), Queen Elizabeth Hospital (Hong Kong), Wellington (New Zealand) and the Monash Medical Centre (Melbourne, Australia), to name but a few of the many.

As an example of current programs available in Australia, the Queensland Health Skills Development Centre offers a "menu" of crisis management courses available for doctors and nurses practicing in: Anaesthesia (ACRM, Recovery Room Crisis Resource Management and elements of the Effective Management of Anaesthetic Crises - EMAC), Emergency Medicine (Emergency Medicine Crisis Resource Management - ECRM), Paediatrics (Paediatric Emergency Crisis Resource Management) and Obstetrics (Maternity Crisis Management Course - MCRM).

In concert with the development of simulation based courses, the necessity for training environments with appropriate equipment (task trainers, simulators, audiovisual support) and personnel (administration, clinical and research staff) has led to the foundation of dedicated simulation centres. The variable investment of healthcare institutions is reflected in the size, resources and scopes of practice of individual centres. Amongst the better resourced facilities in Australia are the Queensland Health Skills Development Centre (Royal Brisbane and Women's Hospital, Herston, Queensland) Southern Health Simulation and Skills Centre (Monash Medical Centre, Victoria), St Vincent's Simulator Centre (Melbourne, Victoria), Sydney Medical Simulation Centre (Royal North Shore Hospital, St Leonards, New South Wales), Clinical Training and Education Centre (CTEC - University of Western Australia, Western Australia). Centres in New Zealand include the National Patient Simulation Training Centre (Wellington) and the Waikato Clinical Skills and Simulation Centre (University of Auckland, Waikato).

The requirements and costs of setting up and maintaining high quality training facilities are substantial. These are well described in a review detailing the development and operation of "CASMS", the Centre for Anaesthesia Skills and Medical Simulation, at the Clinical Training and Education Centre (CTEC) in Western Australia¹². As an example of the financial outlay involved in setting up a centre, the costs of a Laerdal SimMan alone, a commonly used medium fidelity manikin for crisis management training, is in the order of A\$30000. The ongoing expenses of maintaining a running centre are enormous.

Specific crisis management courses are by necessity intensive and personalised with a low participant to facilitator ratio. Coupled with the utilisation of high fidelity scenarios that depend on using sophisticated manikins, confederate actors, realistic moulage and technical support staff,

the costs are substantial. Established centres are consequently under pressure to operate in a "cost-neutral" fashion. For some centres and courses this means that participant learners must pay accordingly for educational experiences. There is additionally an increasing necessity to justify the investments of financing agencies, with the production of evidence describing tangible benefits of courses.

The evidence supporting simulation based medical team crisis management training is not robust. What is known is that simulator training improves confidence and performance when dealing with a simulated scenario for the second time and that healthcare workers generally find simulator training both useful and enjoyable⁷. Some studies have shown an improvement in behavioural performance scores in test scenarios assessed after courses conveying crisis management principles^{11, 13}. Belief in benefit and an acceptance of the rationale for effectiveness have been fundamental requirements motivating early acceptors of simulation in healthcare. Such is the perceived value that in the USA, participation in select crisis management courses have led to significant malpractice premium reductions¹³.

Crew resource management has evolved over 25 years, strongly based on the realisation that 70% of commercial flight accidents stemmed from communication failures among crew members¹⁴. No randomised controlled trials have ever demonstrated a benefit of simulation training, nor can these ever be performed given the ethics of passenger and crew safety. Simulation training was driven by federal mandates that fostered a safer flying environment³. Simulation training made sense and was championed by foresighted individuals who have contributed to a reduction in casualties in the air². Modern flight simulation has been rationalised, with programs of various simulator fidelity and course intensity tailored to specific learning objectives. It is a fundamental educational modality for the training of aviation crews³.

There is strong evidence that in medicine communication failure is also the leading cause of inadvertent patient harm, attributed as the primary root cause of sentinel events in over 70% of cases in some studies¹⁵. Issues such as divergent opinions regarding what is supposed to happen and differing communication styles between doctors and nurses, the hierarchical nature of medical systems with authority gradients and a lack of standardised communication and procedures are major issues. The potential for poor outcomes is magnified by the inherent limitations of human memory, the effects of stress, fatigue, limited abilities to multitask, plus distractions and interruptions to practice¹⁴. Crisis management training is a forum to facilitate the cultural changes needed to facilitate collaborative team environments with effective communication styles that extend to all workplace interactions. Scenario based experiential learning is a rationale means of achieving these goals.

In parallel with the utilisation of simulators for team crisis management training has been the adoption of simulators for skills training. The underlying principal is that the era of "see one, do one, teach one" is no longer acceptable from a patient safety and risk management viewpoint - "See one" "sim one" and "provide a safe practice" is now the order of the day¹⁶. A range of specific skills trainers have become available to teach procedures ranging from vascular access, airway management and chest drain insertion to more sophisticated interventions such as coronary angiography and laparoscopic surgery¹⁷⁻¹⁹. Evidence supporting improved patient performance and a shorter learning curve for skill acquisition is mounting. Discussion regarding the utilisation of simulators for evaluation of professional competency, and as components of maintenance of professional development programs, is beyond the scope of this paper.

The educational paradigm underpinning scenario based simulation training is Kolb's experiential learning theory²⁰. Since the 80's strong support for this theory has evolved with the basic intuitively rational premise being that adults use experience as the source of learning and development. In an increasingly litigious era where practitioner fatigue is appropriately being managed with reduced work hours, real concerns exist that specialists are graduating with insufficient clinical exposure to patients and the spectrum of their clinical problems²¹. Simulated experiences are attractive alternatives if "real" experiences cannot be practically provided. The rationale is that by exposing trainees to important common and rare scenarios, their capacity to subsequently manage these situations in reality should be improved, thereby improving patient care.

Debate exists regarding how "real" the scenarios need to be in order to achieve the most educational benefit for the learner. Emotionality of the experience is thought to be the principal

determinant. The Circumplex Model of Emotion is a two dimensional structure where 16 core affects are described that are deemed to cover all emotional states of individuals at any given time²². These emotions are broadly divided into activated and deactivated states. The activated and deactivated states may be positive or negative emotions. Maximal experiential learning is thought to occur when scenarios deliver participants to an activated zone where predominantly positive but some negative emotions are experienced. For example alert and excited, mixed with some tension and stress. In this activated state learning is recalled when similar states are invoked. Emotional learning may therefore be indelible. Various methods may be employed to achieve this state of activation. High-fidelity manikins capable of speech and breathing, manipulation of physiological variables displayed on monitors and having a range of procedures performed (e.g. intubation, cricothyroidotomy, chest drain insertion, cannulation and fluid administration), housed in a realistic work environment are core. The use of moulage (e.g. realistic wounds, fake blood, clothing, hair) is another commonly utilised component. Confederate actors that drive the realism of situations, create conflict or chaos, as well as assisting in orientating participants to the simulator are useful adjuncts²³. Well scripted and rehearsed scenarios that meet specific educational goals, as part of a considered curriculum, are fundamental²⁴.

Effective, reflective debriefing is mandatory in order to ensure that learners have positive transforming episodes^{25,26}. Much has been written about specific debriefing strategies for medical simulation that are beyond the scope of this paper. This is, however, an area of major importance and concern for providers of experiential learning courses. The educational messages must be cemented with focussed discussion.

Although most participants in CRM courses find them positive experiences, this is not universal²⁷. Medical and nursing staff are frequently high achievers. The simulation environment can create significant anxiety for them and perceived poor performance under scrutiny may be intolerable. In addition to this, potential exists for individual learners to become activated into a state of predominantly negative emotions with the risk of triggering negative emotions and dysfunction when they are re-exposed to a similar scenario in reality. Similarly, activation to highly emotional states may trigger powerful negative emotions from previous unpleasant experiences. Debriefers must be aware of these risks and be equipped and comfortable in looking for and dealing with distressed learners²⁶. There is a paucity of literature pertaining to these important issues and further research into this area is overdue. Anecdotally, many providers of experiential learning for CRM have encountered individual learners that have caused them concerns of this nature. Simulation centres and course providers have an obligation to minimise the risks to learners and provide pathways for managing individuals with persistent difficulties.

To conclude this paper it is interesting to describe the development of a CRM course from its inception. The 'Intensive Care Crisis Event Management (ICCEM) Course' ran its pilot course in December 2006 at the Queensland Health Skills Development Centre. This one day (8 hour) course was directed by me with a foundation faculty targeted based on perceived possession of desirable attributes. These included: enthusiasm for teaching, passion for intensive care and clinical excellence, teamwork and communication skills, affability and open mindedness to adopt new technologies. The team comprised: Dr Jeremy Cohen (Staff Intensive Care Specialist, Royal Brisbane and Women's Hospital and Ipswich Hospital), Dr Leo Nunnink (Staff Intensive Care Specialist, Princess Alexandra Hospital), Dr Shawn Sturland (Staff Intensive Care Specialist, Wellington Hospital), Sarah Webb (Clinical ICU nurse, Royal Brisbane and Women's Hospital), Diana Harvey (Nurse Educator, Mater Hospital Brisbane), Maria Higgs (Clinical ICU nurse, The Prince Charles Hospital) and Raymond Marteene (Clinical ICU nurse, The Prince Charles Hospital).

With a background as an Emergency Physician, in April 2006 I was invited to observe an "ECRM" course, directed at the SDC by a former colleague. It was impressive to observe the sophisticated course delivery and the impact on the participants. I was motivated to develop a CRM course for Intensive care doctors and nurses. Work circumstances placed me in the USA between May and July 2006, during which time I organised to attend the Harvard University (Boston) Institute for Medical Simulation Comprehensive Instructor program. During this immersion I had the opportunity to develop the vision for what has become the ICCEM course,

with the assistance of experienced simulation experts such as Dan Raemer. I also visited the Mayo Clinic Simulation Centre in Rochester, which is run by an Intensivist, William Dunn.

On returning to Brisbane I enlisted the support of Dr Leo Nunnink and Dr Jeremy Cohen as champions of the project and together we developed 6 scenarios that covered a spectrum of ICU crises that would be the springboard for teaching the Harvard Crisis Event Management Principles²⁸. These principles include role clarity, communication, resource utilisation, personnel support and global assessment. With the support of Katie Walker, the Curriculum Development Officer at the Queensland Health Skills Development Centre (QH SDC), we worked with simulation co-ordinators at the centre to develop our scenarios within templates for Laerdal Simman.

After further recruitment of medical and nursing faculty, two formal training days were run at the SDC. The first day was a comprehensive introduction to simulation, CRM training and debriefing with interactive sessions to facilitate mastery of these skills. The second day was run as a 'mock' course. All of the scenarios were tested using faculty rotating through roles as script controller with the simulation co-ordinator, actors, participants, debriefers and debriefing assessors. Additional sessions were held to 'fine-tune' scenarios and moulage, review debriefing strategies and prepare for the pilot course.

A course orientation manual was prepared, that aimed to prepare participants for experiential learning and for how the simulator and environment could be utilised. A resource manual containing modules of key medical information to supplement the individual scenarios learning objectives was also developed. Detailed course evaluation tools, measuring participants medical and CRM knowledge acquisition and reactions to the course and setting were designed with the support of the SDC's Education Evaluations Officer and University of Queensland affiliate, Patricia Rego, who independently performs the evaluation process.

The target group for the course was ICU non-specialist doctors (including registrars, career medical officers) as well as ICU nurses. It was planned that ideally a doctor and nurse pair(s) from individual organisations would attend, so that course principles would be discussed on returning to their workplaces. Course numbers were limited to 8, to maximise the exposure of attendees to the simulator and in keeping with other CRM courses. Time spent developing the course was voluntary and occurred predominantly on rostered days off.

The pilot course was held in December 2006, with 4 doctors and 4 nurses attending the centre from a range of hospitals in Queensland. The response to the course was overwhelmingly positive. Another course was run in February, and was again met with excellent feedback in all domains assessed. Minor changes to the program included the development of a multimedia video that further orientated participants to the simulation environment. Detailed pre-course meetings with faculty occur in the week before the delivery of each course. Further courses are planned during 2007. Over time, simulation co-ordinators (Mr Daniel Host, Mr Dylan Campher and Mr Lucas Tomczak) have become crucial and valued members of the ICCEM course team, contributing to the success of the course in a range of areas including moulage, script translation and involvement in post-course review meetings.

In addition to the comprehensive evaluation program, several additional projects have arisen from the courses development. In response to concerns regarding negative effects on individuals of experiential learning, a follow-up program to screen for psychological stress has been instituted, with the support of a clinical psychologist. An original moulage model that enables chest wall escharotomy to be demonstrated on the manikin without injury has been developed for one of our scenarios. Development of the orientation video required extensive review of the copyright legislation pertaining to the use of commercial multimedia concepts and material. It was scripted and acted as a 'spoof' of the popular medical drama 'House', and incorporated brief segments of music from 'ER' and 'Benny Hill'. Recently we completed a blinded study evaluating costs, realism and practicalities of 15 types of artificial blood that could be employed for moulage in high-fidelity simulation.

The major threat to the continuation of the ICCEM course remains the costs of its delivery. The impact on participants has been extremely positive, but undisputedly this is reliant on the high quality of the course that most likely reflects the sum of the high-fidelity simulation environment, high facilitator to learner ratio and world class facilities. The QH SDC charges participants, who may come from both the public and private sector, for courses at a level that is

'cost-neutral' for them. Currently this translates to approximately A\$1000 for a doctor and nurse pair to attend from an individual institution. These costs are similar for other CRM courses such as ECRM.

There are ongoing discussions regarding ways to reduce these costs and/or obtain supportive funds, in order to facilitate attendance. The challenge is to maintain a level of fidelity compatible with achieving experiential learning.

There remain many unanswered questions regarding team crisis management training. What is known is that it is an effective, engrained component for training professionals in the aviation industry. In medicine it appears rational, it is achievable, albeit at significant cost, and it is well received. Development of the ICCEM course has been a rewarding experience for the team involved and yet the future of the course is uncertain. We believe our role is to foster teamwork and effective communication between professionals. Whether this is through high-fidelity simulation or other more cost-effective techniques, the underlying message is clear - something must be done to reduce the risk to patients imposed by medical teams' communication problems and poor crisis management skills. Our patients deserve it!

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