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The Acute Critical Events Simulation (ACES) Program - A Novel Canadian Educational Initiative to Improve Care of the Critically Ill

BY PETER BRINDLEY, MD; DAVID NEILPOVITZ, MD; JOHN KIM, MD;
PIERRE CARDINAL, MD; AND THE ACES FACULTY

The Acute Critical Events Simulation (ACES) educational program arose from the need to address recurrent deficiencies in the execution of acute resuscitation. This two-day course was designed by intensivists from across Canada to encourage the acquisition of knowledge, procedural skills, and especially behaviours that are essential during resuscitation of the critically ill. The course is notable for its use of portable, high-fidelity, medical simulators, video-debriefing, and multidisciplinary training. The goal is to promote better clinical care, facilitate education beyond merely acquiring didactic facts and, hopefully, decrease the likelihood of adverse events. This issue of *Critical Care Rounds* discusses the origins of ACES and outlines how the program was implemented, evaluated, and modified based on feedback and analysis. This issue also discusses the potential role for crisis resource management (CRM) training in critical care medicine (Table 1) and the use of high-fidelity medical simulators as educational tools (Table 2).

Preexisting critical care education

Several excellent courses already exist for critical care medicine trainees and practitioners, including Advanced Cardiac Life Support (ACLS)[®], Advanced Trauma Life Support (ATLS)[®], and Fundamentals of Critical Care Support (FCCS)[®]. As such, it might be logical to question the need for a program such as ACES. It should be stressed that ACES is not intended to replace these aforementioned courses. However, these courses do not cover all of the aspects of critical care knowledge or factors associated with adverse outcomes.

For example, although the ACLS is an excellent course, it focuses on algorithmic solutions that are applicable only following full cardiovascular collapse. Unfortunately, this is a situation where, regardless of a physician's ability, the outcome is frequently abysmal. In addition, ACLS does not adequately cover airway skills.¹ In contrast, ACES is intended to offer universal strategies that are applicable to cardiac illness, noncardiac illness, and situations where the diagnosis is not yet known and the physician cannot wait before intervening. Of note, ACES focuses on strategies that can be applied earlier, when there is the greatest chance for recovery. In a similar vein, while the excellent FCCS course focuses on factual knowledge and procedural skills, ACES not only covers potential sources of adverse outcome,² but also goes further. For example, it is well-accepted that errors can occur as a result of poor communication and inexperience when managing an evolving medical crisis;²⁻⁵ yet, the skill set referred to as "crisis resource management" (CRM) is rarely taught.⁶⁻⁹ To this end, the ACES program includes video debriefing of participant performance and advice on how to recognize the sick patient, mobilize assistance, act preemptively, and work within a multidisciplinary team, all with the goal of improving patient outcome and decreasing adverse outcomes.

The need to address adverse outcomes and a potential role for education

As many as 98,000 Americans¹⁰ and 23,000 Canadians¹¹ may die each year as a result of medical errors. Although the exact numbers are debated,^{2,12,13} few deny that errors have a



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Correspondence:

John Granton, MD
The Toronto General Hospital
11 NCSB, Rm. 1170
585 University Avenue
Toronto, ON, M5G 2N2
Fax: 416-340-3359

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Table 1: Components of CRM Training¹⁹

- Anticipation and planning
- Communication strategies
- Leadership and assertiveness
- Use of all available resources
- Distribution of workload
- Mobilization of help
- Frequent re-evaluation
- Challenge assumptions
- Concurrent, not sequential management of multi-system illness

CRM = crisis resource management

major effect on patient outcomes and costs. Inexperience, human fallibility, and imperfect work environments contribute to errors occurring in all medical settings.¹⁰⁻¹⁴ Unfortunately, with the critically-ill, decisions are often made under stress and with limited information. This can compound the likelihood of error precisely when the consequences can be most dire. The Canadian National Steering Committee on Patient Safety and the Canadian Patient Safety Institute emphasize that educational initiatives are essential in an effort to reduce adverse events.¹⁴ They also recommend incorporating “simulations of high-risk healthcare interventions.” Medical simulation offers benefits that include the ability to practice actual healthcare delivery and team training, without posing a risk to patients (Table 2). As such, ACES has the potential to be a practical strategy at a time when initiatives are needed.

Physicians need to be more than just medical experts, they also need to be communicators, collaborators, managers, advocates, scholars, and professionals. These skills actually encompass the CanMED objectives, a collection of proficiencies expected of all Canadian trainees.¹⁵ However, these laudable goals can be difficult to teach using traditional methods. While ACES is not a “one-stop solution,” it does partially address several CanMED objectives, including obtaining and synthesizing relevant information, consulting effectively, managing finite resources, working within a team, and responding where advocacy is required. In short, ACES offers a strategy for clinicians, administrators, and educators alike. ACES may also provide a template for others wishing to design courses for their specific needs.

Methods

Implementing a national medical education program

The ACES Program was initiated by the Department of Critical Care Medicine (CCM) at the University of Ottawa following identification of recurrent deficiencies and inexperience with:

- advanced airway control
- the rudiments of mechanical ventilation
- the basic approach to the subtypes of circulatory shock
- a knowledge of vasoactive drugs.

However, in addition to factual ignorance or procedural inexperience, other recurrent deficiencies were

Table 2: Benefits of medical simulation

- No patient risk
- Practice actual healthcare delivery
- Allows wide variety of scenarios, including high-risk low-frequency diseases
- Errors are allowed to be played out
- May repeat as often as required to achieve proficiency
- Recording of performance allows for objective assessment and feedback
- Educators can control material rather than rely on random clinical presentations

identified, including a reluctance to initiate resuscitation until near cardiac collapse, an unwillingness to ask for help, and the inability to direct a team. It became clear that a program was needed that specifically addressed these skills.

The four original modules were airway management, respiratory failure and breathing management, circulatory shock, and CRM/simulation (Table 3).

In response to feedback, the ACES faculty has subsequently increased the time allotted to simulation and added sessions on sepsis, antibiotics, blood transfusion, and gastrointestinal bleeding. A pilot course was presented in December 2001 to an audience that included target populations such as family physicians and residents in anesthesia, internal medicine, and critical care. Following further feedback, the refined course received Continuing Medical Education accreditation from the Canadian College of Family Physicians and the Royal College of Physicians and Surgeons of Canada.

Incorporating high-fidelity simulation into critical care education

The simulation module involves a whole body Laerdal SimMan[®] simulator that is controlled from a laptop computer in an adjacent room. The SimMan

Table 3: ACES Program Modules

| | |
|------------------------------|---|
| A - Airway management | Airway assessment, basic intubation, relevant pharmacology, airway rescue devices, surgical airway |
| B - Breathing therapy | Approach to respiratory failure, oxygen therapy, invasive and non-invasive mechanical ventilation |
| C - Circulatory shock | Approach to shock, vasoactive medications, fluid therapy, central line access, setting up pumps, using monitors |
| S - Simulation/ CRM | Standardized case scenarios presented via high fidelity medical simulator stressing crisis resource management rather than factual knowledge. |
| Additional: | Interactive lectures on blood transfusion, sepsis, antibiotics, gastrointestinal bleeding (first offered in 2003) |

includes a voice simulator that can emit a range of sounds and speech, a realistic modifiable airway that can be intubated, palpable pulses, auscultable lungs and heart, and areas to insert lines and tubes. Respiratory therapists and registered nurses assist the participant and are briefed, but are essentially told to act as they would in everyday practice. They wear headsets in case directions are required. Standard medical equipment, including monitors with all the usual parameters to increase realism, can be modified via computer. Scenarios are given in a standardized fashion and a constructive debrief, including CRM feedback is provided by faculty using the videotape of each performance.

The National ACES course

The principles of ACES were presented to the National Residency Program Directors for CCM and the same resuscitation deficiencies were confirmed by the majority of centres. As a result, it was decided to make the course available to all Canadian CCM residents. Nationwide, faculty members were identified and included experts in clinical resuscitation, the delivery of education, educational research, and business planning. The peer-reviewed national program was first presented in Toronto in 2002. The national course has subsequently moved to Ottawa, Vancouver, and Edmonton, thus confirming its portability, and popularity.

Organization and delivery of an ACES experience

The ACES program offers an ideal adult education experience. It provides basic knowledge, while maximizing guided practice and ensuring individual feedback.¹⁶ The syllabus is mailed beforehand to facilitate pre-study and, before each course, learners are encouraged to identify their own needs. Pre- and postquestionnaires are instrumental in any modifications to the course structure. After introductory presentations, participants rotate through the modules while maintaining a 6:1 resident-to-faculty ratio. This high faculty-to-participant ratio allows for considerable individual attention.

The administrative structure of ACES has been formalized. A not-for-profit company, the Canadian Resuscitation Institute/Institut Canadien de Réanimation, has been established and a website (www.cri-icr.org) facilitates registration and completion of questionnaires. It also serves as a portal to access study material. A manual entitled *Organizing an ACES course* has helped the faculty plan their own courses. Faculty arrive a day early to receive “train-the-trainer” sessions and rehearse. These sessions include peer-driven presentations on how to give feedback, as well as how to operate the simulators.

An extensive pre-course questionnaire determines participant demographics (eg, prior training and resuscitation experience), while an extensive post-questionnaire assesses enjoyment and usefulness of the ACES course. While this article is intended to be predominately descriptive and our statistics are admittedly rudimentary, one of the potential strengths of ACES is its ability to incorporate significant

Table 4: Demographic information on participants

| Variable | | 2002 (n=17) | 2003 (n=32) | Combined (n=49) |
|-------------------------------------|-------------------|----------------|----------------|--------------------|
| Base specialty | Internal medicine | 6 (35.29%) | 15 (46.88%) | 21 (42.86%) |
| | Respirology | 2 (11.76%) | 3 (9.38%) | 5 (10.20%) |
| | Anesthesiology | 4 (25.53%) | 7 (21.88%) | 11 (22.45%) |
| | Emergency | 1 (5.88%) | 2 (6.25%) | 3 (6.12%) |
| | General surgery | 2 (11.76%) | 2 (6.25%) | 4 (8.16%) |
| | Other | 3 (17.64%) | 2 (6.25%) | 5 (10.20%) |
| Finished residency | Yes | 5 (29.41%) | 9 (28.13%) | 14 (28.57%) |
| | No | 12 (70.59%) | 23 (71.88%) | 35 (71.43%) |
| Gender | Male | 13 (76.47%) | 27 (84.38%) | 40 (82%) |
| | Female | 4 (23.53%) | 5 (15.63%) | 9 (18%) |
| Prior simulator experience | Yes | * | 15 (46.88%) | * |
| | No | * | 17 (53.13%) | * |
| | Unknown | * | | * |
| Prior crisis management instruction | Yes | 6 (35.29%) | 8 (25.00%) | 14 (29%) |
| | No | 11 (64.71%) | 24 (75.00%) | 35 (71%) |

* prior simulator experience not asked in 2002

changes based on feedback and this is accomplished from one course to the next. Hopefully, the attention given to feedback permits programs that are better individualized for particular learner groups and in ways not possible with larger courses such as ACLS, ATLS, and FCCS. Our feedback analysis is discussed below using examples from the national ACES courses given in 2002 and 2003 (Tables 4 and 5).

Feedback analysis

For the post-ACES questionnaire, global rating based on a 5-point Likert scale is used. To determine whether a resident's previous training influences the usefulness of the simulator sessions, 4 *a priori* variables have been identified:

- training in an anesthesia residency program (yes/no)
- number of ventilated patients managed per year
- number of times vasopressors/inotropes were used per year
- past experience with simulators (yes/no).

These 4 variables serve as surrogate markers of previous training or experience in airway management, respiratory failure, management of shock, and CRM, respectively. Using multiple linear regression analysis, a simple correlation is used to determine whether taking a previous ACLS or ATLS course influenced the perceived usefulness of the ACES modules.

Results

How well is ACES received?

Overall evaluations have been very favourable (Table 5). On a scale of “0” to “5” (with “5” representing a strong agreement that the course was enjoyable), the rating was 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 useful, with scores of 4.33 (95% CI, 4.01-4.67) for 2002 and 4.37 (95% CI, 4.19-4.55) for 2003. Feedback in 2002 led to more time for CRM/simulation in 2003 and this was

Table 5: Comparison between average evaluation and perceived usefulness scores for 2002 and 2003

| Variable | EVALUATION SCORE | | | Difference | P value |
|--------------------|-------------------|-------------------|------------------|----------------------|---------|
| | 2002 | 2003 | All | | |
| Airway | 4.64 (4.27-5.02) | 4.202 (3.98-4.42) | 4.35 (4.15-4.54) | 0.441 | 0.029 |
| Breathing | 4.679 (4.41-4.94) | 4.456 (4.21-4.70) | 4.53 (4.34-4.71) | 0.223 | 0.253 |
| Circulation | 4.179 (3.59-4.77) | 4.558 (4.21-4.71) | 4.43 (4.22-4.65) | -0.379 | 0.202 |
| CRM / simulation** | 4.011 (3.71-4.31) | 4.671 (4.54-4.80) | 4.53 (4.36-4.71) | -0.66 | 0.0004 |
| Sepsis | n/a | 4.47 (4.28-4.66) | 4.47 (4.28-4.66) | n/a | n/a |
| Infection | n/a | 4.18 (3.89-4.56) | 4.18 (3.89-4.56) | n/a | n/a |
| Transfusion | n/a | 4.52 (4.34-4.70) | 4.52 (4.34-4.7) | n/a | n/a |
| Overall | 4.38 (4.12-4.65) | 4.44 (4.3-4.59) | 4.42 (4.3-4.55) | -0.059 | 0.6545 |
| | | | | PERCEIVED USEFULNESS | |
| Airway | 4.5 (3.83-5.17) | 3.69 (3.2-4.18)* | 3.7 (3.2-4.2) | 0.81 | 0.0524 |
| Breathing | 4.43 (4-4.87) | 4.5 (4.21-4.79) | 4.5 (4.2-4.8) | 0.07 | 0.7759 |
| Circulation | 4.43 (3.8-5.06) | 4.48 (4.24-4.72) | 4.5 (4.2-4.7) | 0.05 | 0.865 |
| CRM / simulation** | 3.93 (3.44-4.42) | 4.76 (4.58-4.94) | 4.5 (4.2-4.7) | 0.83 | 0.0032 |
| Sepsis | n/a | 4.37 (4.05-4.68) | 4.4 (4.0-4.7) | n/a | n/a |
| Infection | n/a | 4.3 (3.92-4.68) | 4.3 (4.0-4.7) | n/a | n/a |
| Transfusion | n/a | 4.52 (4.32-4.72) | 4.5 (4.3-4.7) | n/a | n/a |
| Overall | 4.33 (4.01-4.67) | 4.37 (4.19-4.55) | 4.3 (4.2-4.51) | -0.04 | 0.8625 |

CRM = crisis resource management

* when anesthesia residents are excluded, the mean increases to 4.10 (3.62-4.57)

95% CI = 95 percent confidence interval

n/a = not applicable

associated with significantly increased satisfaction (4.01 in 2002, 95% CI, 3.71-4.31, versus 4.67 in 2003, 95% CI, 4.54-4.80, $p=0.0004$).

Pre-test questionnaires revealed that for critical care trainees, only half had prior simulator experience and one-third had explicit CRM training; 97% had received ACLS and 48% ATLS. In contrast, residents reported that during residency, they had on average, ≤ 15 hours of didactic teaching related specifically to the resuscitation of critically ill patients. Of note, they reported even less direct supervision of their resuscitative skills (Table 4).

We have found that previous training and experience in airway management, respiratory failure, management of shock, and CRM, had no effect on the perceived usefulness of the Circulation and Simulator sessions. Completion of residency training in anesthesia significantly decreased the perceived usefulness of the Airway session ($R^2 = 0.208$, $p = 0.0148$), but had no effect on the perceived usefulness of the Breathing, Circulation, and Simulator sessions. In addition, there was no correlation between having taken ACLS or ATLS and the perceived benefit of the Airway, Breathing, Circulation, and Simulator sessions.

Discussion

ACES is a unique Canadian peer-reviewed educational program that focuses on the knowledge, procedural dexterity, and behaviours required to perform early resuscitation. It is one of the first national courses to emphasize CRM and incorporate medical simulators. Our reviews suggest that the program is very well-received regardless of prior specialty

training or ACLS/ATLS experience. In fact, many participants, including anesthesia trainees, have reported ACES to be the best educational experience they have ever had.

Our questionnaires suggest that there is a notable lack of prior formal training in resuscitation. This is a cause for concern when one considers that this select group has chosen a specialty in which resuscitation is central to practice. When anesthesia trainees are excluded, deficiencies are even more apparent. This presumably reflects the fact that most undergraduate and postgraduate programs do not mandate training in this area.⁶⁻⁸ Presumably, educators hope that trainees gain these skills during residency. However, our data also suggest that trainees are typically unsupervised during resuscitation. Equally apparent is the profound absence of CRM instruction. Deficiencies in CRM have been identified as a major source of medical error and affect practitioners at all levels of experience.⁴⁻⁵ While CRM training is increasing,^{9,17-19} again, most medical schools and residency programs, with the exception of anesthesiology, do not explicitly teach it.^{8,9,19}

CRM is not unique to medicine. Strategies intended to increase recognition of an evolving crisis, facilitate timely intervention, and optimize communication actually originated in the aviation, aerospace, and nuclear power industries.¹⁷⁻²³ As with medicine, errors in these areas carry disastrous consequences. Unlike medicine, however, these other professions have readily adopted CRM training.^{8,9,19,21-23} Barriers to teaching CRM in medicine have included the risk of learning on patients. Fortunately, high-fidelity medical simulators now obviate this concern.^{19,23,24}

Studies demonstrate that participants perceive simulator cases to be highly realistic,^{1,25,26} and that any errors committed are similar to those in real practice.²⁶⁻²⁹ Simulators have been shown to improve skills in airway management,¹ anaphylactic shock,³⁰ malignant hyperthermia,³⁰ and trauma.^{31,32} In addition, simulator education is very well-received,^{1,23,31-33} and lessons learned appear to be retained over time.¹ In addition, medical simulators enable training for high-risk, but low-frequency, situations (eg, the surgical airway, bioterrorism, or even SARS),³⁴ and allow for unlimited practice without risk to patients or healthcare workers.

With simulators, trainees can be intentionally exposed to critical incidences, near misses, and crises. Interestingly, it has been suggested that learning from adverse events that occur during real practice can be suboptimal due to poor reporting and denial of personal responsibility.²³ With simulators, mishaps can be reviewed openly without concern for liability, blame, or guilt. Furthermore, simulators allow educators to determine educational content rather than relying on ad-hoc clinical availability. With the reduction in trainee working hours and reduced on-call expectations, training programs may not be able to ensure sufficient experiential learning. When combined with decreased public acceptance of physicians honing their skills on the public, simulators have the potential for widespread use both for initial training and maintenance of skills. As is the case for pilots, it is quite possible that acute care practitioners will be mandated to undergo routine simulator practice. After all, why should patients expect less than airline passengers and why should medicine tolerate error rates far higher than in the aviation industry?

ACES focuses upon non-punitive feedback rather than ascribing a pass-fail grade. This was a deliberate decision, since our goal was to facilitate learning instead of ascribing a grade. Typically, only half of our participants have had prior simulator experience. Therefore, performance may be hindered by a lack of familiarity as opposed to a deficiency in ability or skill. In addition, the anxiety caused by being scored might decrease the educational value of the simulator. It remains to be seen if continued familiarity with simulators will allow them to be used as formal evaluative tools. Initial studies comparing simulation to standardized examinations suggest that simulator performance does correlate with experience,^{31,33} but does not always correlate with written grades.³⁵ However, rather than dismissing their utility, these questions should be answered – Which testing format better assesses actual delivery of care? Do simulator grades and written grades determine different skill sets? Regardless, it presents a fertile area for research. Unfortunately, however, this has led to some reluctance towards investment in medical simulators. Of note, the airline and nuclear industries have widely incorporated high-fidelity simulators without the perceived need for validity studies.^{21,22}

Clearly, a more comprehensive pre- and post-test study could be conducted. Pre-test surveys do not assess competency, they simply document prior training and they are also prone to reporter bias. Post-test surveys are equally crude with participants simply providing a global assessment of the program. Thus, it may be difficult to more precisely quantify the benefit of ACES, given the absence of a gold standard test for CRM. Complex prospective outcome studies comparing participants and nonparticipants are planned. Interestingly, although the ACLS, ATLS, and FCCS have never been prospectively shown to improve outcome, they have been widely accepted nonetheless.

ACES is a valuable experience for faculty. It provides an opportunity to develop and share educational material. It also fosters ties between institutions and has germinated other initiatives, including the coordination of multicentre educational research and the development of pediatric ACES. Given the importance of language to CRM, we are also finalizing the full ACES program in French. ACES is an important part of the annual critical care calendar. It represents the only national educational session for CCM trainees and offers them the first chance to meet together and to network.

The ACES Program is obviously no panacea. However, it represents a practical strategy for clinicians striving to provide exemplary acute care, administrators eager to decrease adverse outcomes, and educators wishing to expand learning opportunities. We hope our experience will inspire others to harness the breadth of medical educational expertise and enthusiasm in Canada. We also hope that this country can lead in the reduction of adverse events.

Editor's note

Integration of knowledge, technical skills, communication, and effective leadership of a multidisciplinary team, in an environment that is confounded by the acuity of patients and complexity of technology and therapeutic modalities, is a challenge to educators and practicing clinicians. The ACES program is currently used to facilitate the instruction of critical care medicine trainees across Canada. However, its design and portability allow it to be used in a variety of situations with a range of curricula and learners. Adult learning requires that information be conveyed in an active learning environment. As professionals, we are increasingly called upon to revise our approach to practice and demonstrate competence in an evolving discipline. In this regard, programs such as ACES will likely become the new standard of instruction in critical care.

Peter Brindley, MD; David Neilipovitz, MD; John Kim, MD; and Pierre Cardinal, MD; are part of the ACES Faculty. The entire faculty and their university affiliations are listed on the next page.

The ACES faculty

Dr. Fred Baxter, McMaster University
Dr. Dean Bell, University of Manitoba
Dr. Peter Brindley, University of Alberta
Dr. Fabrice Brunet, University of Toronto
Dr. Don Burke, Sudbury Regional Hospital
Dr. Pierre Cardinal, University of Ottawa
Dr. Lois Champion, University of Western Ontario
Dr. Chris Christodoulou, University of Manitoba
Dr. William Gallacher, Dalhousie University
Dr. John Granton, University of Toronto
Dr. Richard Hodder, University of Ottawa
Dr. Dev Jayaraman, McGill University
Dr. John Kim, University of Ottawa
Dr. Sheldon Magder, McGill University
Dr. David Neilipovitz, University of Ottawa
Dr. Juan Ronco, University of British Columbia
Dr. Yoanna Skrobik, Université de Montréal
Dr. Randy Wax, University of Toronto
Ms. Maia Pudifin, University of Ottawa

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Upcoming meeting

26-28 October 2005

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CONTACT: www.tcems.com

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