Use of a fully simulated intensive care unit environment for critical event management training for internal medicine residents*

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Management of inpatient emergencies (including "codes") in teaching hospitals is often the responsibility of trainees in internal medicine. In such settings, successful implementation of therapeutic plans requires a technically competent leader who is able to coordinate the entire team's effort. Leadership requires acquiring and interpreting patient information, choosing and prioritizing tasks to be accomplished, assigning them to specific individuals, and repeatedly reevaluating the results of therapy. Most residencies do not offer systematic training in crisis management leadership beyond limited portions of advanced cardiac life support certification. Crisis management skills are important in other medical fields, and specialized simulation-based curricula have been used in these settings for some time (1–6).

Members of our group pioneered the development of crisis-management and teamwork training for anesthesiologists based in part on the curriculum of Crew Resource Management (CRM) taught in commercial aviation. In the 1980s, research in aviation demonstrated that a large proportion of aircraft accidents were linked to failures on the part of crews with appropriate technical skills to manage their resources effectively (7). In an effort to address the shortcomings of decision-making and teamwork skills of cockpit crews, airlines in the United States joined with NASA and the U.S. military in establishing CRM training (8).

Similarly, in health care, many accidents seemed due to nontechnical aspects of the work of individuals, teams, and systems. Thus, by analogy to the aviation curriculum, the Anesthesia Crisis Resource Management (ACRM) course developed in 1990 emphasizes nontechnical skills of decision making and team and resource management (2, 9) (Table 1). A textbook on the principles of CRM in anesthesiology (with content highly applicable to critical care) has been available since 1994 (2).

The decision-making components of critical care deal with cognition in highly dynamic environments that differ from those encountered in the outpatient clinic or the wards. In such environments, diagnosis, monitoring, and therapy are completely interleaved and iterated rapidly, often including hands-on implementation by an integrated team rather than simply writing orders for later execution. In these dynamic settings, issues of allocation of attention, use of redundant information, and repeated situational reevaluation are paramount. The team and resource management components deal with the ability to translate the knowledge of what needs to be done into effective team activity in the complex and ill-structured real world of an intensive care unit (ICU) or ward emergency response team. Here, issues of leadership and followership are important, combined with the communication skills needed to create effective teamwork. Being able to identify, mobilize, and use the technical, human, and organizational resources of the ICU and the hospital is crucial.

CRM-based simulation training for anesthesiologists and other medical specialties has spread widely since 1990, being adopted most notably at Stanford and Harvard in the United States and at a number of centers around the world, including centers in the United Kingdom, Australia, New Zealand, Switzerland, Denmark, and Germany (6, 10–16).

The ACRM-like approach has been codified, and specialized instructor training programs are offered by the initial centers of excellence (4, 17). Other approaches to applying CRM to health care also have been described, such as Team Oriented Medical Simulation (18, 19). To date, a simulation-based crisis management curriculum has not been offered to internal medicine house staff in the intensive care setting. We describe the initial evaluation of a crisis management curriculum that has been taught during our medical surgical ICU rotation for the past 2 yrs.

The major goal of the course is to combine didactic teaching with an experience representing what a practitioner might encounter in a real medical setting. Four elements were essential: a) providing a reasonable replica of both the human aspects and physical environment surrounding medical emergencies; b) presenting "cases" that challenge both the medical and nontechnical skills of trainees; c) allowing residents to experience managing the cases themselves without direction from an expert attending; and d) providing participants with detailed review of their performance, using self-critique by the individuals involved, their peer group, and expert instructors. The title of the course is Improving Management of Patient Emergency Situations (IMPES).

*See also p. 2553.

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METHODS

Curriculum Structure. The IMPES course is held monthly, typically at the midpoint of the monthly ICU rotation. Since September 2000, we have conducted 23 courses for 181 total participants. The curriculum consists of two components.

Didactic and Group-Work Session. The first component of the course is a 1-hr didactic and group-work session, held as part of a regular daily teaching lecture, where the principles of crisis management are discussed (1, 2).

As a brief introduction to sources of human error, we view and discuss a short video reenactment of a classic accident case in aviation. The trainees then work as a group to analyze and discuss a "paper case" of a patient on a hospital ward who develops upper gastrointestinal hemorrhage and cardiac ischemia. Issues related to the management of resources including physician time, attention, and the impact of interventions on final outcome are evaluated.

Simulator Session. On another day, the residents participate in two critical event scenarios in a simulator facility that replicates an ICU. A computerized mannequin (MedSim Eagle Patient Simulator) serves as the patient (Fig. 1). It allows spontaneous and mechanical ventilation, routine and invasive monitoring, and a number of physical signs (1–3). Through a speaker mounted behind the head, the mannequin is also a "standardized patient," with the voice provided by an instructor in the adjacent control room. All physiologic, pharmacologic, and anatomical variables respond to the therapeutic interventions according to the mathematical models in the simulator, with additional manipulation as necessary by instructors. The entire scenario, including data displayed on the physiologic monitors, is videotaped for subsequent review during debriefing. Additionally, we encourage the participants to "think out loud" as a tool for reconstructing the actions and thoughts of participants (20, 21).

Each critical event scenario begins with an intern being called to the "ICU" and presented with an ill patient by a course instructor acting as a departing "night float resident." A patient chart is provided along with lab data, radiographs, electrocardiograms, and other relevant information. A naive ICU nurse, also undergoing the training, is present at the bedside. Invasive monitors can be activated if participants go through the motions of inserting catheters using standard kits (however, they do not actually cannulate the mannequin). Relevant physiologic waveforms as well as pulse oximetry and noninvasive blood pressure data are displayed in real time on the clinical monitors. If additional blood gases, labs, radiographs, or electrocardiograms are desired, participants must go through the appropriate steps to obtain the data. A crash cart containing a modified defibrillator is also available. The trainees can call in a respiratory therapist, a medical or surgical resident (postgraduate year 2–3), or an anesthesia resident if additional help is desired. Frequently, an ICU fellow is available for backup. All participants are asked to come equipped as they would for any patient encounter; cognitive aids such as drug-dosing books, reference cards, calculators, or hand-held computers are encouraged. An additional "resource/facilitator nurse" (who is a course instructor) is present at the bedside.

Table 1. Key Points of Intensive Care Unit Critical Event Management

Decision-Making and Cognition	Team and Resource Management
Know your team and environment	Take a leadership role
Anticipate and plan	Call for help early
Allocate attention wisely	Communicate effectively
Use all available information and cross check it	Distribute the workload
Use cognitive aids (e.g., checklists, reference materials)	Mobilize and utilize all available resources

Figure 1. ICU team managing a simulated unstable patient. The medical intern (*center*) and surgery resident (*foreground*) discuss data and treatment options while a medical student, pharmacist, and respiratory therapist look on.

Each patient presents with a primary disturbance (i.e., either respiratory or hemodynamic) on a background of underlying comorbidities. The clinical course of each patient depends on the interventions chosen by the treating team: notably, how promptly they recognize an abnormality, how effectively they organize themselves to complete key tasks (establishing adequate intravenous access, monitoring, and administering antibiotics, oxygen, and vasoactive medications), and how well they are prepared for contingencies. We reinforce the reality that for a given abnormality, a large set of diagnostic and therapeutic options exists. For example, in our respiratory distress scenario, multiple modalities for respiratory support in addition to mechanical ventilation are available: Down's flow generator, noninvasive bilevel positive airway pressure, venturi mask, resuscitation bag, and nonrebreathing masks. In this way, we emphasize clinical decision making over the execution of a select set of tasks.

Generally, the patients' response to therapy as well as the occurrence of secondary events (e.g., arrhythmias or bronchospasm) takes place in a physiologically plausible manner through a variety of pathways (Fig. 2 illustrates a respiratory distress scenario). If effective action is not taken in a reasonable time, the patient may develop a cardiac arrest. If so, successful resuscitation can be accomplished by applying standard advanced cardiac life support therapies in a coordinated fashion.

Debriefing Session. Each scenario lasts between 30 and 40 mins, and after each, a 35-min debriefing session is conducted by an ICU attending/course instructor who has received special training in critical event debriefing. During this time, participants are led through a detailed discussion of their experiences. Debriefing is an integral part of the process of any experiential learning technique. In general, both medical and resource management aspects of patient care are discussed while participants review the pros and cons of the actions taken and the other available alternatives. We make ample use of the videotapes, which allow simultaneous replay of all camera views and patient data monitors. As facilitators, we strive for an atmosphere of constructive critique and feedback provided in a supportive, nonjudgmental manner. We use leading questions such as those in Table 2 to help participants appreciate the concepts of crisis resource management.

Logistics and Manpower, ICU Staffing. Excluding medical students, each 4-hr session at the simulation center involves as participants six ICU residents (typically four from internal medicine and one each from anesthesia and surgery), a nurse, a respiratory therapist, and sometimes an ICU fellow. Clinical coverage of the ICU is provided for by an ICU attending and fellow. The instructor/simulation team includes two ICU attendings, an ICU nurse, and the simulation center manager.

Course Evaluation. Following each simulation/debriefing session, the trainees completed a three-page anonymous questionnaire concerning their attitudes and experiences with the course. All questions solicited responses on a 5-point Likert scale (strongly disagree to strongly agree). Survey response data were not normally distributed and therefore are presented as median scores and are evaluated for intergroup differences by chi-square distribution and by Spearman rank correlation coefficient and the Kruskal-Wallis,

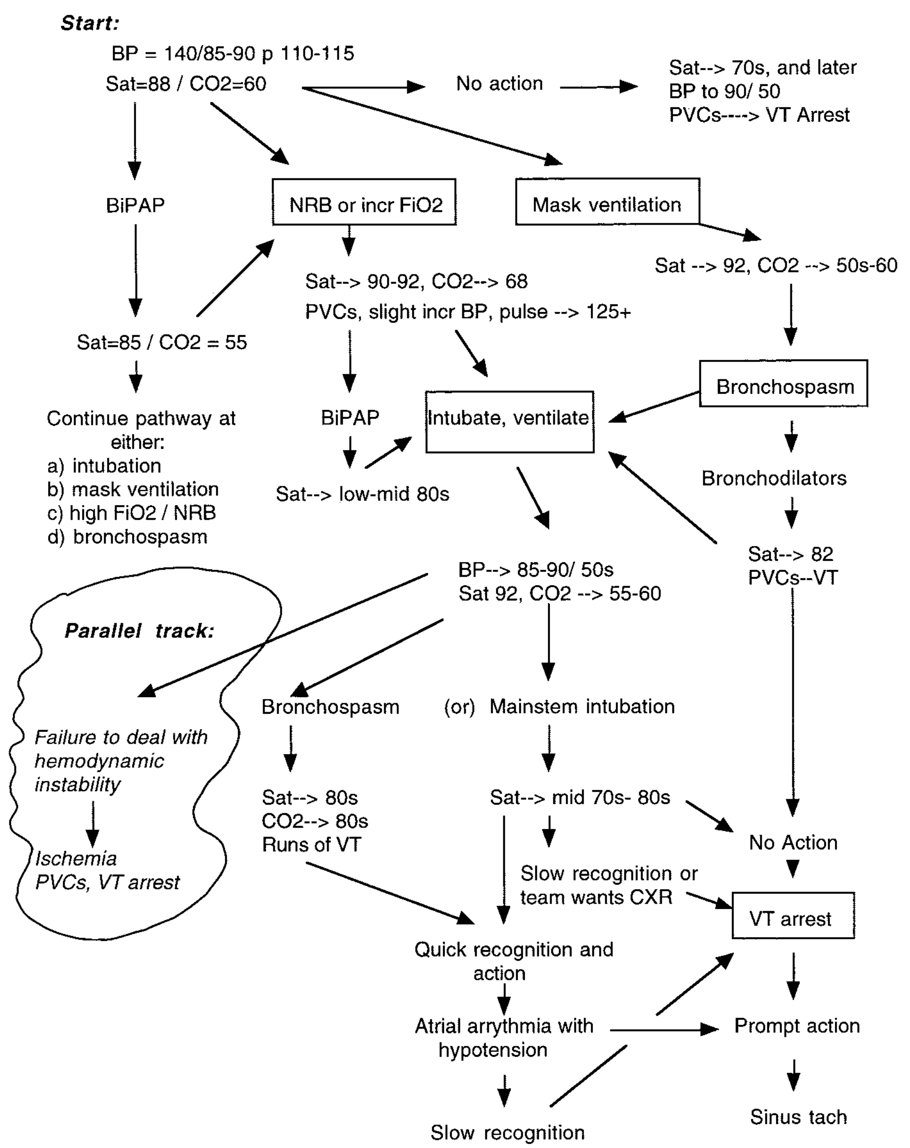

Figure 2. Flow chart describing a simulated respiratory distress scenario. The scenario has an identical start point for all groups managing this "patient." Subsequently, the direction taken is based on decisions made by the treating physicians, with the most common pathways shown. *BP*, blood pressure; *SaO_2*, arterial oxygen saturation; *PVC*, premature ventricular contraction; *VT*, ventricular tachycardia; *BiPAP*, noninvasive bilevel positive airway pressure; *NRB*, 100% oxygen given by nonrebreathing mask; *Sat*, percent oxygen saturation of arterial hemoglobin; *CXR*, chest radiograph.

respectively, for two- and three-group comparisons. This educational evaluation has been approved as "exempt" by the Institutional Review Board of Stanford University and the VA Palo Alto Health Care System.

RESULTS

Observations and Survey Results. Demographics of course participants are provided in Table 3. The full set of responses to the postcourse questionnaire is presented in Table 4. The responses indicate that participants considered the course a valuable training experience suitable for all levels of house staff, that the simulator environment was realistic, and that all three course components (didactic, simulator, and debriefing) were deemed valuable. The vast majority of respondents (85%) believed the course should be offered every 6–12 months. We analyzed in detail the responses of residents in internal medicine, anesthesiology, and surgery. For all questions, responses were not normally distributed among the five response categories, with the overwhelming majority being the positive responses, "agree" or "strongly agree."

Using the survey responses, we investigated whether the self-perceived educational value differed by medical discipline or by level of training within the internal medicine cohort. Median data for questionnaire responses of medical, surgery, and anesthesia residents are presented in Table 5. Responses were uniformly favorable (all median responses were either agree or strongly agree), with all disciplines reporting the course to be well suited for their level of training. In general, the surgery residents showed a tendency toward a lower median response in the postcourse survey than residents in medicine and anesthesia ($p < .05$ for se-

Table 2. Common Bebriefing Questions

Who is in charge?
Who is watching the patient?
Does the whole team, including ancillary personnel, understand the working diagnoses and priorities?
When do you call for help?
How were priorities conveyed to the team?
Did participants understand their roles and expectations?
What key tasks are present in the scenario?
Were some key tasks not completed?
Were personnel overutilized or underutilized?
What type of talents and capabilities do specific individuals have? Were these talents used appropriately?
Was the leadership style effective? Was it open to input and suggestions?

Table 3. Survey Respondents

	Number
Medical students	25
Medical housestaff, total	(73)
Medical interns	55
2nd- and 3rd-yr medical residents	18
Anesthesia housestaff	18
Surgery housestaff	18
ICU fellows	11
Nursing staff	12
Respiratory therapists	15
Unidentified responders	8
Total respondents	181

Table 4. Intensive Care Unit (ICU) Simulator Survey Responses by All Housestaff Participants

Questions	Responses, %					
	No Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The nurses were realistic and believable in the simulator environment	0	1	1	2	26	70
The video cameras did not interfere with the simulator experience	0	1	5	3	26	65
I felt that the simulation environment and scenario prompted realistic responses from me	1	0	4	7	37	51
I felt that I did things during the scenario that I would never have a chance to practice otherwise	0	3	11	22	32	33
I expect that the knowledge gained about the scenarios will be helpful to me in my practice	0	0	1	2	32	65
I expect that the knowledge gained about CRM will be helpful to me in my practice	0	1	0	4	30	65
I encountered situations during the scenario that I now want to learn more about through reading, lectures, and conferences	0	0	1	5	41	53
The debriefing session clarified important CRM issues in the scenario	0	0	1	3	43	54
The debriefing session added to my learning experience	0	0	3	2	33	63
The debriefing session enhanced my fund of knowledge	0	0	3	5	43	50
There was effective interaction between the instructor and the trainees during the debriefing session	0	0	1	2	37	60
I enjoyed the ICU simulator course	0	0	1	4	22	74
The course was intense	0	0	5	14	40	42
I learned a lot	0	0	1	4	43	53
This course will help me practice more safely	0	0	1	4	35	60
This course is well suited for initial residency training	0	1	0	2	27	70
This course is well suited for advanced residency training	1	1	0	4	28	66
This course is well suited for refresher training	1	1	1	3	25	70
This course is well suited as part of a recertification program	2	1	0	5	28	64
This course is well suited for equipment evaluation	1	1	2	20	26	50
This course is well suited for ICU team coordination training	2	1	0	1	32	65
This course should be taken	7%, no response	0%, never	1%, >24 mos	5%, every 24 mos	37%, every 12 mos	49%, every 6 mos

CRM, Crew Resourse Management.

The original questionnaire contained 30 items; nine items addressing quality control issues of the course have been removed from this table.

lect questions presented in Table 5). There was only one question where the response of the medicine interns differed from that of the upper level residents (bottom of Table 5); for this item, responses from the medicine interns accounted for the difference between medicine and anesthesia and surgery residents.

Observations of Performance in Managing Medical Crises. We have yet to systematically quantify the performance of trainees during crisis management, concerning either their medical/technical management or their nontechnical skills. However, our observations indicate a number of errors that occurred with high frequency (Table 6). The group of residents who watched the scenario unfold via the TV monitors easily recognized many of these errors in progress. In the debriefings, there was unanimous acknowledgment among course participants that such errors are everyday occurrences in medical emergencies.

DISCUSSION

Several aspects of our program are unique to both internal medicine and critical care training. It is the first reported use of CRM-oriented patient simulation training for internal medicine trainees in the ICU. By incorporating patients undergoing rapid physiologic changes with the medicines, equipment, and personnel of the ICU, we have found that the dynamics of critical care can be realistically replicated for teaching purposes. An overwhelming majority of participants found the scenarios and environment to be lifelike, demanding decision making and interpersonal interactions similar to those of real crises.

The training experience is interdisciplinary both among physicians and between physicians, nurses, and other allied health professions. Although the course largely focused on the training of physicians, all participants contributed to and benefited from the debriefings. Each discipline and culture bring different skills and perspectives to the management of medical problems. It is our intention that these discussions plant seeds that may result in long-term culture change concerning patient safety.

Videotaping the scenarios provides an impartial view of human performance during critical events and is a potent tool for resident training. There rarely is the opportunity to review recordings of real events. Even if such review were possible, the training experience for a cohort of residents would not be consistent due to the nonuniform distribution of cases and uncertainty as to the actual underlying causes of the events. Debriefings of group performance in the simulator may be the

Table 5. Responses to Select Questions by Medical Discipline[a]

Questionnaire Item	Medicine	Anesthesia	Surgery
Knowledge gained about crisis resource management will be helpful to me in my practice	5 (4–5)	4 (4–5)	4 (3.3–5)[b]
I encountered situations that I now want to learn more about through reading and conferences	5 (3.2–5)	4 (4–5)	4 (3–5)[b]
Course will help me practice more safely	5 (4–5)	5 (4–5)	4 (3–5)[b]
Course is well suited for initial residency training	5 (4–5)	5 (4–5)	4 (3–5)[b]
Course is well suited for advanced residency training	5 (4–5)	5 (4.4–5)	4 (3–5)[b]
Course is well suited for ICU team coordination	5 (4–5)	5 (4–5)	4 (3–5)[b]
I learned a lot	5 (4–5)	5 (4–5)	4 (3–5)[b]
I encountered situations that I now want to learn more about through reading and conferences	5 (3.2–5), med interns		4[c] (3.4–5), med residents[d]

ICU, intensive care unit

[a]*Median score (5%–95% percentile for each response);* [b]Significant by chi-square distribution and by Kruskal-Wallis test with corrections for ties at $p < .05$; [c]significant by chi-square distribution and by Spearman vs rank correlation with corrections for ties at $p < .05$; [d]second- and third-year internal medicine residents. Survey scale: 1 = strongly disagree: 2 = disagree: 3 = neutral: 4 = agree: 5 = strongly agree.

Table 6. Commonly Observed Errors in Critical Care Simulations

Type of Error and Example	Impact
Technical	
Improper drug selection	
Epinephrine for hypotension with tachydysrhythmias	Increase in HR, PVCs
Drug dose errors	
1 mg of epinephrine for MAP of 50	Hypertension
Dopamine dose not increased for persistent hypotension	Prolonged shock state
Co_2 detector not used (while available)	Unrecognized esophageal intubation and hypoxemia
Failure to initiate CPR, defibrilate end-organ damage	
Failure to administer antibiotics in septic patient	Underlying abnormality not treated
Vigilance and fixation errors	
Failure to notice dysrhythmias on monitor	Unrecognized deterioration
No recognition of BP cuff not cycling	Unrecognized deterioration
No response to ventilator alarms	Unrecognized bronchospasm, hypoventilation
Failure to periodically check patient status while placing a line	Unrecognized worsening hypotension, hypoxemia
Preoccupation with requests for lab or diagnostic studies	Resources diverted from stabilizing patient
Judgment	
Med student places catheter in deteriorating patient	Inappropriate delay of therapy
Complacency with grossly abnormal vital signs	Clinical deterioration
No inquiry into code status	May change management
NTG given for ST changes in hypotensive patient	Primary abnormality not corrected
Communication	
No follow-up inquiry on requested lab studies	Forgotten requests not identified
Failure to communicate priorities	Insignificant tasks get done instead
Nurse overloaded with requests	Key tasks not executed in timely manner
Lack of leadership	Ineffective use of time, personnel
Nurse or respiratory therapist initiates therapy without knowledge of the treating physician	Patient status not fully appreciated

HR, heart rate; PVCs, premature ventricular contractions; MAP, mean arterial pressure; CPR, cardiopulmonary resuscitation; NTG, nitroglycerin.

next best thing and is certainly more attainable.

Because we are teaching the course to a group of individuals at different levels of expertise and from multiple medical disciplines, the postcourse questionnaire helped reassure us that all participants believed they had benefited from the course. The only striking finding from the questionnaire was a generally higher rating of the course by medicine and anesthesia residents as opposed to surgery residents. The reasons for this are unclear. It may be that that the role of surgeons in "codes" in our training program is more technical (i.e., catheter and chest tube placement). The simulation environment did not allow actual conduct of these procedures. In addition, in surgical training, multidisciplinary teamwork is emphasized less than the role of performing operative procedures. It is also possible that these simulator scenarios may not seem as relevant to surgical trainees as would be scenarios based on surgical patients and postoperative complications. Anesthesia residents in our training program, on the other hand, are very familiar with simulation-based training, as they take a different level of ACRM each year of their residency. Since the interns were the initial physicians to receive the unstable patient in the simulated exercises, they assumed the burden of early decision making and leadership. The general tempo and trajectory of the scenario were usually set by the interns' initial actions. Despite the potential for higher scrutiny, the comments and survey responses from the interns did not reflect dissatisfaction, frustration, or any higher level of stress than that reported by other trainees.

Need for Specialized Training in Crisis Management and Nontechnical Skills. Is there a need for such specialized training, or do residents already possess the technical and behavioral skills for managing

> *This team training potentially could enhance other interventions to improve the management of patient emergency situations.*

codes and patient emergencies? Our observations of errors in standard simulations (Table 6) suggest that the cognitive and teamwork objectives of our course are relevant to improving care of unstable patients. Caring for unstable patients is typically an area of residency where trainees are expected to learn what to do "by osmosis" and by observing role models. Yet, in many settings, only residents manage the emergencies, and attending physicians typically are called in last. Moreover, few attending physicians outside of highly dynamic domains like the emergency department, ICU, or operating room are good role models of crisis management leadership. Having solid proof that crisis simulation training improves patient outcomes would certainly validate the time and resources devoted to this curriculum. However, we are not at a stage where such assessments can be made, and this may be an inappropriately high standard for medical training. For example, certification in advanced cardiac life support gained acceptance and had been required for all house staff and for hospital accreditation decades before better outcomes were associated with this training (21).

Ironically, discussions with course participants suggest that the potential for technical training on the medical management of specific crisis situations most excites the house staff—especially the interns. As effective crisis management must be built on a foundation of sound medical knowledge and skill, the drive to acquire more experience and practice managing unstable patients in a controlled setting is certainly understandable. Our questionnaire data suggest that the circumstances encountered in one or both scenarios may be an intern's first exposure to managing such a condition, so it is not surprising that the intern would want to first master the technical aspects before becoming concerned with how to manage the situation as a whole. Perhaps the more senior residents, having experienced the "loneliness of command," are more interested in considering the human factors of critical patient management. Indeed, courses do exist where the primary objective is to introduce new physicians and nurses to a comprehensive patient assessment system; they are not simulator-based and tend to reinforce standard pathways in clinical problem solving (22). In contrast, the IMPES course focuses more on complex behaviors such as leadership, resource utilization, and situational awareness—elements that provide an ultrastructure to critical event management. With an increasing number of internal medicine practices based in outpatient clinics, training in crisis management skills may be of greater long-term value and relevance for the occasional emergency encountered in such practices than programs where skill development or algorithm acquisition is the primary objective.

This team training potentially could enhance other interventions to improve the management of patient emergency situations. In two historically controlled studies, hospital mortality rate and incidence of cardiac arrest calls both were reduced by the presence of a multidisciplinary team charged with evaluating and stabilizing patients according to predefined physiologic variables (23, 24). As opposed to a cardiac arrest team, a "rapid response team" is likely to encounter a wider array of potential diagnoses, the latter much less amenable to published treatment algorithms and standardized drug doses. It is reasonable to expect that event management training like that described here would complement efforts at implementing "early intervention" programs.

To date, CRM-oriented training in health care has developed from the strong face validity of the approach and the clear connection to cognitive parallels in aviation. The simulation-based ACRM-like curricula have had indirect validation from questionnaire data (1, 3, 25), anecdotes of clinical experiences after simulation (26, 27), and the widespread adoption of the approach. But to what extent do simulated exercises predict or improve behavior in true emergencies? This is a difficult question to answer because there is no gold-standard method to measure performance—either in the simulator or (even less so) in real case management. Studies involving anesthesiologists suggest that such measurements in the simulator are difficult but feasible (4, 28, 29). We are currently designing ways to evaluate whether specific classroom-type instruction on managing unstable patients can translate to better performance during simulated patient emergencies. Extending these assessments to real patient care settings will be a difficult challenge. Finally, with a renewed national focus on limiting resident work hours, residency programs will have to concentrate training on activities that have the highest potential for skill and knowledge retention (30). The role of simulator training as part of a medicine curriculum is quite promising and should be examined in this light.

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