ELSEVIER
SAUNDERS

Anesthesiology Clin
25 (2007) 301–319

ANESTHESIOLOGY
CLINICS

Simulation: Translation to Improved Team Performance

Elizabeth A. Hunt, MD, MPH[a,*],
Nicole A. Shilkofski, MD[a],
Theodora A. Stavroudis, MD[b],
Kristen L. Nelson, MD[a]

[a]*Johns Hopkins Simulation Center, Department of Anesthesiology and Critical Care Medicine, Johns Hopkins University School of Medicine, 600 North Wolfe Street, Blalock 904, Baltimore, MD 21287, USA*
[b]*Johns Hopkins Simulation Center, Department of Pediatrics, Johns Hopkins University School of Medicine, 600 North Wolfe Street, Nelson 2-133, Baltimore, MD 21287, USA*

The practice of medicine is becoming increasingly complex. No one individual can expect to care for a patient on their own, and must interact with other disciplines and specialties to optimize care. Traditional medical education has emphasized autonomy and, until recently, issues related to teamwork have not been explicitly included in medical curriculum. In addition, medicine has traditionally been very hierarchical, emphasizing a communication structure that follows a chain of command philosophy. Although this type of communication is effective in some realms, it has been shown to contribute to errors in a variety of disciplines.

Recent medical literature highlights that over two thirds of serious medical errors called "sentinel events" and reported to the Joint Commission on Accreditation of Healthcare Organizations were primarily caused by failures in communication [1]. In their 1999 report that showed that as many as 98,000 patients in the United States die each year because of medical errors, the Institute of Medicine highlighted that health care providers tend to be trained as individuals, yet function almost exclusively as teams, creating a gap between training and reality. The Institute of Medicine suggested the use of simulation exercises focused on improving teamwork as one of the mechanisms to improve patient safety [2].

* Corresponding author.
E-mail address: ehunt@jhmi.edu (E.A. Hunt).

1932-2275/07/$ - see front matter
doi:10.1016/j.anclin.2007.03.004 *anesthesiology.theclinics.com*

This article reviews important concepts related to teamwork and discusses examples where simulation either could be or has been used to improve teamwork in medical disciplines to enhance patient safety.

Teamwork

Teamwork is a very complex example of human interactions that has been studied at length by organizational and human factors psychologists. A team represents a group of individuals who must work together to perform a common goal. Ideally, a team represents a type of synergy, in that a well-functioning team should be able to do things more effectively, efficiently, reliably, or safely than an individual or a group of individuals working separately could do had they been alone. A poorly functioning team, however, may be antagonistic and detrimental to productivity.

Beaubien and Baker [3] define teamwork as "those behaviors that facilitate effective team member interaction." A review of the medical literature reveals a number of concepts related to teamwork that have now been applied to medicine. Although the terminology regarding these concepts may vary, there are specific behaviors that are repeatedly mentioned and either have been or may be addressed through simulation and are briefly highlighted here (Box 1).

A recurrent theme in teamwork literature is the need for effective communication. The key is to ensure that team members are not merely working alongside one another in parallel, but are actually interacting in a way that makes "the whole greater than the sum of its' parts." Characteristics that enhance effective communication are paramount. For example, a good leader is capable of giving instruction in a manner that ensures that the instruction is heard, understood, and heeded (or if the follower cannot heed the instruction, they communicate that back to the leader).

A practical example

In a series of 35 simulated pediatric medical emergencies (mock codes) conducted on pediatric in-patient wards, in every mock code there was at least one order given by the leader, and assumed to be completed, that was discovered to be incomplete only during debriefing [9]. For example, in scenarios of septic shock, the residents invariably believed that the simulated patient had received 40 to 60 mL/kg of fluid boluses by the end of the 20-minute scenario. On interviewing the nursing staff during debriefing, however, the resident discovered that the nurse had put the bolus on an intravenous pump to run over an hour per usual protocol, because they had not been given a specific instruction in terms of time for completion of the bolus. The nurse further clarified that they had either not heard the instructions for the subsequent boluses or had planned to administer them

Box 1. Characteristics associated with high-performing teams

Situation Awareness (SA): Team performance is improved when team members continually assess their environment and update each other in a process called ''shared cognition,'' so that they are making decisions based on current information and can have a shared mental model of the current state of affairs and an updated plan of action with contingencies. SA allows team to maintain a big picture view of situation. Effective military and aviation teams have higher SA than low-performing teams [4–6].

Leadership: An effective team leader can both command the team and values input from team members. Flattening the hierarchy improves safety because information can flow in both directions, whereas leaders who maintain an authoritarian type of leadership ''reinforce large authority gradients, creating unnecessary risk.'' A leader should try not to perform procedures unless the procedure is essential and no one else is capable of doing it. Stepping back and keeping a bird's eye view allows the leader to take in and process more information and contributes to situational awareness [5–7].

Followership: The nonleader members of the team are called ''followers.'' Good ''followership'' is just as important for good team functioning as good leadership. Followers need to know their individual role on the team but also contribute to overall team functionality. They must contribute to situational awareness by verbalizing observations about changes in the environment, ideas about diagnosis, to decrease the leaders' workload if necessary, and finally to help the leader avoid mistakes (eg, ''the team leader might focus on an incorrect diagnosis and apply the wrong rule [treatment] owing to a fixation error, or be incapacitated, hence everyone in the team should always be alert''). Finally, followers must not assume that the leader knows everything and should feel obligated to share observations that might impact outcome [5,7].

Closed Loop Communication: Closed looped communication is used to ensure that a message that was sent is heeded and understood, and involves ''[1] the sender initiating a message, [2] the receiver receiving the message, interpreting it, and acknowledging its receipt, and [3] the sender following up to insure the intended message was received'' [4].

Critical Language and Standardized Practices: ''Critical language'' refers to the use of a catch phrase that means something to

every member of an organization and requires specific action (standardized practices). United Airlines developed the CUS program, for ''I'm concerned, I'm uncomfortable, this is unsafe, or I'm scared,'' and is adopted within the culture as meaning ''we have a serious problem, stop and listen to me.'' Another example of a standardized approach to improve the effectiveness of communication is SBAR (situation, background, assessment, recommendation). This is a tool that gives an outline of how ''awareness and education regarding the fact that nurses, physicians, and other clinicians are taught to communicate in very different styles'' [4,6].

Assertive Communication: Safe patient care may depend on the ability of a team member to speak up and get the attention of other team members when they believe something might be going wrong. This is more likely to happen if a team member believes speaking up will not be held against them. A recurrent phrase is that people can still show deference to expertise, but speak up in a ''non-threatening and respectful manner.'' The idea is all team members may have valuable input, ''regardless of rank.'' The ''hint and hope'' model has been described as a common and dangerous way of trying indirectly to communicate with other team members [4–6].

Adaptive Behaviors: Teams whose members are flexible and perform as needed to optimize team functioning and demonstrate adaptive behaviors are those that can truly benefit from the synergy of an effective team. Examples of adaptive behavior that optimize team functionality include: ''(a) team members ask for help when overloaded, (b) team members monitor each others performance to notice any performance decreases (mutual performance monitoring), or (c) team members take an active role in assisting other team members who are in need of help (backup behavior). An essential component to the above actions happening is trust among team members'' [4].

Workload Management: Workload management is dependent on team members demonstrating adaptive behaviors. This principal requires (1) proper allocation of tasks to individuals; (2) avoidance of work overloads in self and in others; (3) prioritization of tasks during periods of high workload; and (4) preventing nonessential factors from distracting attention from adherence to protocols, particularly those relating to critical tasks [5].

Debriefing: Debriefing is the process of reviewing a simulation or real event after it is complete to optimize any lessons that can be learned. When using simulation as a teaching tool, simulation with no debriefing and feedback does not result in effective learning. In terms of real events, teams that debrief themselves afterward have been shown to be higher performing [8].

when the first was done, but did not want to bother the physician to clarify the situation.

Two techniques that can improve communication are for the leader to give the order followed by a specific team member's name to increase the likelihood that the order will be heard, and to use the technique of closed loop communication [4]. The leader gives the command, the follower repeats the command, allowing the leader to know it was heard and interpreted correctly, and the leader confirms what they have heard. Although it is very important that a good leader ensure that their orders have been heard and interpreted correctly, it is equally important that the other team members practice good "followership." They should participate in the closed loop communication, speak up when they are unable to complete the command to improve the team's situational awareness, and use assertive communication techniques to clarify if they do not agree or are concerned about the order. Flattening the hierarchy so that the followers feel comfortable speaking up to the leader is essential to create an environment where followers can point out that they have not yet completed an order or do not agree with the order (see Box 1).

In the previously mentioned case, the resident as team leader was operating on the assumption that the child had received almost 60 mL/kg of fluid boluses and was in some type of fluid-resistant shock, whereas that child had actually received less than 20 mL/kg. This gap between the leader's mental model of the situation and the truth may have a truly negative impact on the child's care and has been observed in reality by the authors when accepting patients in septic shock transferred from various emergency departments. The incongruence between the physician and nursing reports highlights that the team is not on the same page. By debriefing the team members after a real or simulated crisis, however, this lack of situational awareness and closed loop communication can be highlighted and the team members have an opportunity to learn from this mistake. Furthermore, simulation allows the team members to repeat portions of the exercise and to practice communicating with one another until they are truly functioning as a team, all without harming a patient.

In their simulation group, the authors have used simulation as part of an iterative process that allows them to (1) diagnose deficiencies in knowledge, technical skills, or teamwork; (2) create opportunities to practice the deficiency; and

(3) reassess for improvement. The mock codes on the wards revealed this disconnect between the "two islands" (ie, physician and nursing staff). The authors have subsequently used a number of simulation forums to allow pediatric residents and nurses to practice a variety of skills, including those related to teamwork. For example, residents practice giving clear orders for fluid boluses, including explaining out loud their goals of the fluid resuscitation as dictated by shock guidelines, and the nurses practice communicating that they have heard the order and to update the resident when the order has been completed or if they cannot complete the order as directed. Also, an opportunity is taken to explain how fluid can be delivered much faster by pushing with a syringe or using a pressure bag than through a pump, addressing a knowledge deficiency that they can then practice in the next simulation. The key to making these sessions productive is to follow educational principles that highlight the need for having clear educational objectives before each exercise and debriefing afterward to highlight lessons learned and yet to be learned. In this case the objectives might be as follows: (1) knowledge: fluid can be delivered faster by pushing the fluid; (2) technical: actually hook up the IV to a stopcock and IV bag and practice delivering quickly; and (3) teamwork: practice closed loop communication, assertive communication, and situational awareness.

These are just a few of the teamwork characteristics used by highly functioning teams and highlighted in Box 1 and more extensively in the teamwork literature. Now reviewed is the concept of simulation; a brief history, including how aviation transitioned from using simulation for technical skills to prioritizing team training; and examples of teams that can or have used simulation to improve the practice of medicine.

Simulation

Simulation refers to the recreation of an actual event that has previously occurred or could potentially occur. One of the greatest values of simulation is that it can be used over and over again to perfect an action, a procedure, or a conversation without ever exposing the providers or patients to harm. Today, simulation is used in many industries to promote and improve team communication and construction, procedural skill training, educational evaluations, and technologic innovations, such as the usability of devices.

Historical perspective

Leading the way: simulation in aviation

Historically, one of the earliest applications of simulation began with the development of the world's first flight simulator in 1911 by Orville Wright and later with the Link trainer [10,11]. Rolfe and Staples [11] describe the development of flight simulation as a "logical approach to teaching," by using an environment similar to the actual cockpit while still being "safely

linked to the ground.'' Simulation was then used to train pilots how to fly for both military and commercial aviation. Unfortunately, despite technologic advances in aviation and early use of simulation, plane accidents with great loss of human life occurred. To determine why such accidents occurred, it eventually became extremely important to understand the team dynamics in the cockpit. Simulation, however, had not yet been used to evaluate flight team performance or communication; it had only been used to train pilots to fly. When the source of most flight error was eventually determined, the multidimensional aspects of simulation developed.

Transition from technical training to teamwork training

Originally, individual pilot error was most often quoted as the source of aviation-related accidents. In 1979, however, the Aerospace Human Factors Research Division of the National Aeronautics and Space Administration revealed that communication errors, inefficient leadership and coordination skills, and faulty decision-making in crisis situations were more often to blame [12,13]. Accidents were found to be associated with inadequate team communication as opposed to improper individual performance, and shortly thereafter Cockpit Resource Management (CRM) was created [12,13].

Cockpit-crew resource management

CRM is now a well-known, structured curriculum in the aviation industry. The original curriculum was designed to teach flight crews how to communicate effectively as a team and to evaluate their leadership and resource management skills in crisis situations. The focus was the multiperson crew in the cockpit [5]. Subsequent evaluation revealed, however, that critical interactions occurred between the cockpit crew and the remainder of the flight crew, and the name of the program was changed from ''Cockpit'' to ''Crew Resource Management'' and is now being applied to all divisions within the aviation industry [5,13].

CRM teaches that all members of a team are vital. If a team member at any level believes that something is not being done appropriately or in the best interest of the team or other people that have put their trust in the team, then that member must speak up. The fact that humans make mistakes, but are able to learn from these errors and prevent their repetition, is an important tenant of CRM training.

CRM uses simulation and team debriefings not only to teach team communication, but also to highlight errors in the simulated setting in the hopes of avoiding the same errors in an actual event involving humans. The cognitive stress associated with crisis situations can be created or recreated through the use of simulated events potentially to determine where, when, and why errors occur in such situations. Over time, commercial pilots were involved in simulations for both the technical and teamwork

components of flying, but were only tested on their technical skills, detracting from the importance of the crew training. In the late 1980s, it was recognized that human factors were still contributing to 70% of accidents, and at that time the Advanced Qualification Program, which combined training and testing of both technical and teamwork skills, was implemented [5]. This move represented a huge shift in the approach to training and maintenance of certification for aviation crew members. Teamwork training had become equally important to technical training.

Simulation: application to medicine

Although flight simulation in aviation had its beginnings in 1910, the history of medical simulation using mannequins as partial task trainers dates back to the 1960s with the creation of Resusci-Anne and the Harvey cardiology simulator [14]. Progressively sophisticated and economical computer-driven mannequins, capable of several physiologic actions, have created a more realistic representation of the human patient and are being used for increasing fidelity of simulations used in medical trainings.

The medical community is now highlighting simulation training as the cornerstone to achieving some degree of competence before performing skills on patients, to protect patient safety. The authors' group has coined the phrase "practice on plastic first" to highlight this premise. Although practice is used in this phrase, it is the deliberate practice of a skill in context that is of importance. To achieve perfection of a skill requires dedicated, repetitive training with debriefing to highlight errors or progress.

Simulation for medical team training

David Gaba and others have pioneered the application of simulation training to the medical community, following many of the tenants of aviation training. Gaba and colleagues designed a mannequin-based simulator program known as "Comprehensive Anesthesia Simulation Environment" in the late 1980s. In these situations, human performance was evaluated during anesthesia crisis situations. Application of such evaluations to an anesthesia curriculum resulted in the development of what is now often referred to as "anesthesia crisis resource management" [15,16]. Although originally used in anesthesia, anesthesia crisis resource management has several applications to other divisions within health care, and reference to CRM for the remainder of this article refers to crisis resource management.

CRM training in medicine involves many of the same principles that are found in aviation training, including the three crucial tenants of CRM training: (1) knowledge, (2) practice, and (3) recurrence [17]. Simulated scenarios are used to evaluate team performance in many areas, such as the operating room, trauma bay, and in ICUs, and in events in which small management errors can have grave consequences, such as in cardiopulmonary arrest or

in the transport of critically ill patients. CRM training also involves the use of feedback or debriefing sessions as a vital component for process improvement.

The Agency for Healthcare Research and Quality has defined three categories of competencies that are necessary for a team to operate effectively: (1) teamwork-related knowledge, (2) skills, and (3) attitude. Knowledge constitutes an understanding of the requisite skills required for tasks that the team is responsible for, whereas teamwork skills refer to the ability to interact as a team in a proficient and efficient manner. Although these skills are key components of a team, an attitude of trust among members and a desire for improving patient safety are also fundamental to maintenance of a high-quality team [17]. Through the use of simulation, these requisite team components can be rehearsed, allowing team members not only to practice the necessary technical skills, but also to learn to build team trust.

Debriefing

The importance of debriefing after a team simulation experience cannot be overemphasized and is fully reviewed by Randolph elsewhere in this issue. Debriefing allows the team to learn where errors occurred and how they could potentially have been prevented, but it also allows recognition of areas of appropriate performance. Simulation without debriefing has been shown to be ineffective, because errors can be repeated if team members have not been informed that they were making mistakes [8]. In a study by Savoldelli and colleagues [18], those residents who received audio or visual feedback following a simulated scenario performed significantly better on subsequent scenarios than their counterparts who had not received debriefing. Through the use of CRM simulation training and debriefing, health care providers at all levels can learn effective team training in a variety of simulated scenarios, thereby fostering an environment ultimately conducive to patient safety.

Operating room teams

Surgical procedures involve complex, interdisciplinary team communication and have been shown to be responsible for significant morbidity and mortality for patients when errors occur. The operating room can be a highly stressful environment with team members from different disciplines, such as surgery, anesthesia, and nursing, all with different levels of training (attendings, residents, new nurses), who may have met infrequently or never before. Simulation training and debriefing can help the team prepare and anticipate potential adverse events in a complex environment, hopefully avoiding error or subsequently preventing error in repeat interactions.

Simulation in the form of role-playing has been used to practice ''time outs'' before surgery, to decrease the incidence of wrong site surgery. Actors

playing the part of an authoritarian surgeon have been used to train anesthesia and nursing staff how to use assertive communication to enhance patient safety. Simulation has been used to plan complex surgeries, such as separating conjoined twins. At the Johns Hopkins Children's Center, the anesthesia, neurosurgical, plastic surgery, and operating room staff teams worked together to plan a complex surgery including simulating how they would flip the joined children supine in the event of a cardiac arrest while prone. These simulations allowed them to work out problems ahead of time and make sure that they had all the appropriate equipment and job assignments. Varying levels of mannequin-based simulation have also been successfully applied to the operating room arena. Performance assessment of both technical and team communication skills have revealed improved learning through simulation [19,20].

Use of the operating room debriefing tool developed by Makary and colleagues [21] during operating room simulations, as is done after real procedures, may highlight both errors and accolades of an operating room team to determine ways to improve patient safety and give teams practice in using the tool. This tool involves a checklist, to be completed by the team at the completion of a procedure, that allows the team to "assess the cause(s) of an adverse event, near miss or inefficiency." All members of the team are present for this debriefing and are expected to verbalize any concerns pertaining to the case. Implementation of this tool has led to important patient safety modifications. Furthermore, because of its' success in this environment, it is now being applied in other environments outside of the operating room, such as in ICUs.

Obstetric teams

Obstetric teams can also benefit from simulation team training. Difficult deliveries and medical emergencies, such as shoulder dystocia, placental abruption, eclampsia, fetal distress, and multiple gestations, can be simulated with the potential complications associated with each type of event. Through simulation, a labor and delivery room can be recreated and all of the team members can practice their roles, including the obstetrician, anesthesiologist, nurses, and the pediatricians. Thompson and colleagues [22] reported the use of eclampsia drills to identify deficiencies in team preparation for this type of emergency. This type of drill is most effective if all parties that participate in a real event also participate in the simulated events.

Intensive care unit teams

ICUs in adult, pediatric, and neonatal settings are composed of highly dynamic teams that must act quickly in the face of often unanticipated crisis situations. Critically ill patients often require constant physiologic monitoring with complex and evolving technologies. All members of these teams must be trained to manage and communicate effectively and efficiently with these patients and their families. In these circumstances, simulation can provide

a replication of the ICU environment, equipped with the technology, including the actual models of equipment that will be encountered in the ICU. Complex scenarios that require successful team interactions can be simulated to help prepare staff for real events, such as cardiopulmonary arrest, difficult airway crises, elevated intracranial pressure, shock scenarios, and the need to "crash onto extracorporeal membrane oxygenation."

Procedures performed in the ICU can also be simulated, such as central venous line insertion, including the gowning procedures to ensure sterility, the technical skill of the insertion itself, and any potential team dynamics. For example, one could create a simulation where a new fellow (actor) is putting in a central line but allows the wire to touch a nonsterile part of the field. The goal of the simulation is for the nurse to notice this break in sterility and use assertive communication tactfully to insist that the fellow stop the procedure until a new wire is available. Another example is to have an ICU physician examine a simulated patient on isolation. The nurse should point out tactfully if the doctor did not wash their hands or put on isolation garb, allowing the team to practice the dynamic of assertive communication that is respectful, but prioritizes the patient's safety over the health care provider's ego. The exercise is repeated until the nurse feels comfortable making the intervention and the physician receives the information with grace and complies with protocols. Team training must focus on both sides of a communication.

Another teamwork issue, lack of leadership, has been sighted as a common error in simulated ICU crisis situations [23]. Lack of leadership often leads to communication mishaps and delays in therapy. The use of didactic education, simulation, and debriefing sessions to replicate such situations have been implemented as part of CRM training at Stanford University for internal medicine trainees rotating through the ICU and have been favorably received as a valuable teaching tool with considerable realism [23].

Another role for simulation in the ICU is to improve communication skills related to discussions about the futility of medical therapy; end-of-life decisions; and the chronicity of medical care, such as long-term mechanical ventilator management and insertion of gastrostomy tubes. Williams [24] ran multidisciplinary ICU teams through simulations with standardized actors playing family members of a person with a severe traumatic brain injury that evolves to brain death. The simulation involved functioning as a team to prepare the family for progression to brain death and then approaching them about organ donation. This exercise was well received by participants and the intervention was associated with increased organ donation rates, presumably because of more effective communication postintervention [24].

Additionally, because ICUs have significant technology that is ever-changing, new devices are often introduced that require retraining of all involved staff. The usability of such complex medical devices can be tested before purchase. In addition, actual models of equipment used in the ICU should be used

during team training to increase fidelity. For example, in simulated cardiopulmonary arrests, the authors' team has discovered a lack of familiarity with the defibrillator, particularly the pacing module. They have used simulations of pediatric patients with extremely poor perfusion caused by bradycardia to teach ICU teams how to set up the transcutaneous pacemaker. They purposely do not allow the pacemaker to capture until they have reached a predetermined energy output. They then allow the high-fidelity mannequin to have a slightly improved but not adequate blood pressure. Only if the team notices this and decides to increase the paced heart rate, (because the teams invariably pick a rate that is inadequate for a stressed child) does the child's perfusion improve. This ability to test the interface between medical equipment and personnel during team training is invaluable [25].

Neonatal intensive care unit teams

Studies have identified shortcomings in providers' adherence to the Neonatal Resuscitation Program guidelines [26,27]. In 2000, Carbine and colleagues [26] videotaped neonatal resuscitation skills in the delivery room and found that 54% of 100 neonatal resuscitations deviated from Neonatal Resuscitation Program guidelines. Thomas and colleagues [28] conducted focus groups of nurses, staff nurses, residents, fellows, and attending physicians from the neonatal ICU and found that consistent descriptions of teams or teamwork did not exist. It was noted that hierarchy within groups had a powerful and complicated influence on the way providers communicated with each other, including difficulty in questioning those with authority.

Thomas and colleagues [28] developed 10 behavioral markers for evaluating teamwork in neonatal resuscitation based on standards used in the aviation industry:

1. Information sharing
2. Inquiry
3. Assertion
4. Intentions shared
5. Teaching
6. Evaluation of plans
7. Workload management
8. Vigilance and environmental awareness
9. Overall teamwork
10. Leadership

Using this behavioral marker tool to assess delivery room resuscitations, leadership and assertion were observed in 20% of cases, evaluation of plans in 13% of cases, and intentions stated in only 9% of cases [29]. Moreover, on reviewing 300 videotaped high-risk deliveries at their institution, Finer and Rich [30] also found problems involving teamwork including inappropriate leader and team member activities, inappropriate preparation,

communication, and coordination. They suggested that neonatal resuscitation could be improved by the provision of teaching about team and leader functions and encouraged debriefing following complicated resuscitation. Although these studies reveal that certain components of teamwork are lacking in neonatal resuscitations and that this is an area for improvement, further work is needed to decipher the magnitude of this problem and its' effects on delivery room outcomes.

The first high-fidelity simulation-based training program in neonatal resuscitation was developed at Stanford University in the mid-1990s and was well-received by trainees [31]. In addition to emphasizing technical skills, this program also stresses behavioral skills and teamwork skills. Halamek and colleagues showed that trainees believe that this type of training better develops behavioral and critical thinking skills in addition to their technical skills [32]. Currently, a prospective, controlled trial is underway to evaluate objectively the transfer of skills from the simulator to the real environment [32]. Team training courses have also been developed by Ostergaard and colleagues [7] at the Danish Institute for Medical Simulation in response to safety initiatives aimed at improving lack of decision-making skills and absence of teamwork.

Rapid response teams and code teams

A code team or a rapid response team may include people from many disciplines, including physicians (potentially from various specialties); nurses; respiratory therapists; pharmacists; and chaplains. Simulation has been used as both a training tool and as a diagnostic tool to assess how well code or rapid response teams function in their own environment. Evidence gathered from simulated medical emergencies, including cardiopulmonary arrests, demonstrated that these teams were not able efficiently to deliver care; follow appropriate algorithms per American Heart Association Guidelines; or use resuscitation equipment, such as defibrillators, successfully [9,33,34]. These findings were subsequently confirmed in a study of real in-hospital cardiopulmonary arrests [35]. DeVita and colleagues [36] demonstrated that rapid response team training using simulation could improve the functioning of a team and adherence to American Heart Association guidelines.

Transport teams

Both interhospital and intrahospital transport of patients is often necessary. Adequate preparation of such teams is paramount for ensuring patient safety. Studies have shown, however, that teams unfamiliar with the required equipment and the potential adversities that may arise during the transport of patients, particularly those who are critically ill, may lead to an increase in serious complications for the patient [37].

Through the use of simulation, such transport events can be simulated to ensure proper preparation and team communication. Having a team run through a simulated scenario of transporting a patient to the radiology department for a CT scan may reveal previously unrecognized needs. ''Is the oxygen tank full, is there a mask of appropriate size available for the intubated patient should the endotracheal tube become dislodged,'' are common needs on a transport of a critically patient, but can be easily overlooked. The necessary equipment for each transport also needs to be anticipated. Repeated practice can make the tasks more manageable and it is hoped increase the safety of the patient. Furthermore, transport team simulations allow each member to evaluate their roles during the process. Who is going to be responsible for maintaining the IV pumps or who is going to ensure that the end tidal CO_2 monitor is working before and during transport are common tasks that must be assigned and receive follow-up.

Such teams must be able to communicate with one another to ensure that all patient safety features are in place. A transport checklist may assist in ensuring that all jobs have been assigned. The transport team leader should be identified and be ultimately responsible for ensuring the checklist is complete before transport. Both the creation and completion of the checklist can be simulated repeatedly until perfection is achieved. The importance of such collaboration of team members has been highlighted by Flabouris and colleagues [38], who found that good teamwork skills (42%) and good interpersonal communication (4%) were associated with decreased adverse events during transport of critically ill patients. Furthermore, in their review of components of effective neonatal emergency transport networks, Lupton and Pendray [39] cite the importance of establishing team leadership, distribution of workload, stress management, and effective communication among the constituents of a neonatal transport team.

Trauma teams

A trauma team is a cross-functional and multidisciplinary team that can potentially include surgeons, anesthesiologists, intensivists, nurses, respiratory therapists, technicians, and resident physicians. Team membership and function is fluid, depending on patient needs. Trauma teams accomplish their task under a severe information shortage, with patients often brought in unconscious and with little information accompanying them [40]. Simulation can assess both technical performance and behavioral attributes of a team [41].

Several types of simulation have been involved in training trauma teams. The Advanced Trauma Life Support course has variably used animals, partial task trainers, standardized patients, and moulage and high-fidelity mannequin simulators [42]. In addition to skills training, simulation can provide the foundation for team training, including planning, anticipation, establishment of leadership, delegation and distribution of job tasks, consideration

of treatment options, review of data, and decision making [42]. Although many simulation studies focus on individual performance, it is widely recognized that optimal trauma care is delivered by experienced and coordinated multidisciplinary teams.

Shapiro and colleagues [43] showed that simulation-based teamwork training improves clinical team performance in an emergency department trauma setting. Their intervention consisted of an 8-hour intensive experience with an emergency department simulator in which scenarios of graduated difficulty were encountered. The experimental team showed a trend toward improvement in the quality of team behavior. In addition, members of the experimental team rated simulation-based training as a useful educational method for enhancing didactic teamwork training. This approach, they concluded, was more representative of clinical care and the proper paradigm in which to perform teamwork training.

Lee and colleagues [44] conducted a study during surgical intern orientation at two academic trauma centers in which interns attended a basic trauma course and were then randomized to trauma assessment practice sessions with either a patient simulator or a moulage patient. Mean trauma assessment scores for simulator-trained intern teams were higher than for moulage-trained intern teams. Marshall and colleagues [45] studied teams of interns who participated in trauma scenarios on a human patient simulator pre and post an Advanced Trauma Life Support provider course and concluded that use of simulation in conjunction with Advanced Trauma Life Support seems to enhance the development of trauma team management skills.

Another study of team behavior in trauma team performance was performed by Holcomb and colleagues [46] using human patient simulators. The study evaluated teams of three members: physicians, nurses, and medics rotating through a civilian trauma center at the beginning and end of the rotation. The 10 teams were compared with expert teams composed of experienced trauma surgeons and nurses. The results showed significant improvement after participation in the rotation, primarily reflecting improved efficiency and coordination of team efforts. The scores of the experimental teams after the rotation approached those of the expert teams. The study concluded that simulation may better prepare teams for the clinical arena, and refresh skills and decision-making processes for uncommon or infrequent occurrences. It also indicates that it is possible to quantify improved performance and to differentiate between experienced and novice teams.

Finally, simulation has been used in emergency departments to diagnose deficiencies in team management of pediatric trauma [47]. A study of simulated mock traumas performed at 35 North Carolina emergency departments revealed problems with pediatric-specific tasks, such as appropriate use of intraosseous needles, weight-based dextrose and volume replacement, and poor preparation for transport to CT. In this study, teams were

evaluated to identify possible targets for educational and system-wide interventions that might have the potential to improve the outcomes of pediatric trauma victims [47].

Future directions

The principles of CRM from aviation have been successfully transferred to medical teams. The literature supporting the effectiveness of simulation training to improve teamwork is in the early stages, however, and has not yet been linked to improved patient outcomes. The simulation community must now make a focused effort to use scientific principles to optimize the effect of medical simulation on patient safety. Future use and study of simulation to improve team training should include (1) known educational principles, such as designing curriculum with specific technical and teamwork objectives and use of debriefing; (2) use of existing and development of new validated measures of teamwork as outcome measures; (3) study of decay in teamwork skills so that appropriate intervals for retraining can be determined; and (4) the development of multicenter networks that have the power to detect if team training has an impact on clinical outcomes and patient safety.

Summary

Medical teams require practiced interactions and communications to be effective and efficient. A flattened hierarchy allows for the flow of information to and from the leader. There are a number of teamwork principles that can be practiced to optimize the synergy of a team, including leadership, followership, situational awareness, closed loop communication, critical language and standardized responses, assertive communication, adaptive behaviors, workload management, and debriefing.

The multiple modalities of simulation can be used to optimize team functioning and to ensure achievement of the common goals of these teams, of which patient safety is paramount. ''Teams make fewer mistakes than do individuals, and this is especially true when every member of a team is as aware of their teammates' responsibilities as they are their own'' [17].

References

[1] Joint Commission on Accreditation of Healthcare Organizations. Joint Commission International Center for Patient Safety. Communication: a critical component in delivering quality care. Available at: http://www.jcrinc.com/publications.asp?durki=10719&;site=153&return=11558. Accessed October 15, 2006.

[2] Kohn LT, Corrigan JM, Donaldson MS. To err is human: building a safer health system. Washington, DC: National Academy Press; 1999.

[3] Beaubien JM, Baker DP. The use of simulation for training teamwork skills in health care: how low can you go? Qual Saf Health Care 2004;13(Suppl 1):i51–6.
[4] Burke CS, Salas E, Wilson-Donnelly K, et al. How to turn a team of experts into an expert medical team: guidance from the aviation and military communities. Qual Saf Health Care 2004;13(Suppl):i96–104.
[5] Hamman WR. The complexity of team training: what we have learned from aviation and its applications to medicine. Qual Saf Health Care 2004;13(Suppl 1):72–9.
[6] Leonard M, Graham S, Bonacum D. The human factor: the critical importance of effective teamwork and communication in providing safe care. Qual Saf Health Care 2004;13(Suppl 1):i85–90.
[7] Ostergaard HT, Ostergaard D, Lippert A. Implementation of team training in medical education in Denmark. Qual Saf Health Care 2004;13(Suppl 1):i91–5.
[8] Issenberg SB, McGaghie WC, Petrusa ER, et al. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach 2005; 27(1):10–28.
[9] Hunt EA. Simulation of pediatric cardiopulmonary arrests: a report of mock codes performed over a 40 month period focused on assessing delays in important resuscitation maneuvers and types of errors. Presented at the 4th International Meeting on Medical Simulation. Albuquerque (New Mexico), January 2004. Available at: http://www.anestech.org/Publications/IMMS_2004/Hunt.pdf. Accessed October 17, 2006.
[10] Mohler SR. Human factors of powered flight: the Wright brothers' contributions. Aviat Space Environ Med 2004;75(2):184–8.
[11] Rolfe JM, Staples KJ, editors. Flight simulation. Cambridge (England): Cambridge University Press; 1986. p. 14.
[12] Oriol MD. Crew resource management: applications in healthcare organizations. J Nurs Adm 2006;36(9):402–6.
[13] Helmreich RL, Merritt AC, Wilhelm JA. The evolution of Crew Resource Management in training in commercial aviation. Int J Aviat Psychol 1999;9(1):19–32.
[14] Gaba DM. The future vision of simulation in health care. Qual Saf Health Care 2004; 13(Suppl 1):i2–10.
[15] Howard SK, Gaba DM, Fish KJ, et al. Anesthesia crisis resource management training: teaching anesthesiologists to handle critical incidents. Aviat Space Environ Med 1992; 63(9):763–70.
[16] Cooper JB. Are simulation and didactic crisis resource management (CRM) training synergistic? Qual Saf Health Care 2004;13(6):413–4.
[17] Baker DP, Gustafson S, Beaubien J, et al. Medical teamwork and patient safety: the evidence-based relation. Literature review. Rockville (MD): Agency for Healthcare Research and Quality; April 2005. AHRQ, Publication No. 05-0053. Available at: http://www.ahrq.gov/qual/medteam/. Accessed October 13, 2006.
[18] Savoldelli GL, Naik VN, Park J, et al. Value of debriefing during simulated crisis management: oral versus video-assisted oral feedback. Anesthesiology 2006;105(2):279–85.
[19] Moorthy K, Munz Y, Adams S, et al. A human factors analysis of technical and team skills among surgical trainees during procedural simulations in a simulated operating theatre. Ann Surg 2005;242(5):631–9.
[20] Aggarwal R, Undre S, Moorthy K, et al. The simulated operating theatre: comprehensive training for surgical teams. Qual Saf Health Care 2004;13(Suppl 1):i27–32.
[21] Makary MA, Holzmueller CG, Sexton JB, et al. Operating room debriefings. Jt Comm J Qual Patient Saf 2006;32(7):407–10.
[22] Thompson S, Neal S, Clark V. Clinical risk management in obstetrics: eclampsia drills. BMJ 2004;328(7434):269–71.
[23] Lighthall GK, Barr J, Howard SK, et al. Use of a fully simulated intensive care unit environment for critical event management training for internal medicine residents. Crit Care Med 2003;31(10):2437–43.

[24] Williams M. Interdisciplinary experiential training for end-of-life care and organ donation. Presented at the National Consent Conference on Organ Donation. Orlando (FL). April 28–30, 2003.
[25] Hunt EA, Nelson KL, Shilkofski NA. Simulation in medicine: addressing patient safety and improving the interface between healthcare providers and medical technology. Biomed Instrum Technol 2006;40(5):399–404.
[26] Carbine DN, Finer NN, Knodel E, et al. Video recording as a means of evaluating neonatal resuscitation performance. Pediatrics 2000;106(4):654–8.
[27] Thomas EJ, Sexton JB, Lasky RE, et al. Teamwork and quality during neonatal care in the delivery room. J Perinatol 2006;26(3):163–9.
[28] Thomas EJ, Sherwood GD, Mulhollem JL, et al. Working together in the neonatal intensive care unit: provider perspectives. J Perinatol 2004;24(9):552–9.
[29] Thomas EJ, Sexton JB, Helmreich RL. Translating teamwork behaviours from aviation to healthcare: development of behavioural markers for neonatal resuscitation. Qual Saf Health Care 2004;13(Suppl 1):57–64.
[30] Finer NN, Rich W. Neonatal resuscitation: toward improved performance. Resuscitation 2002;53(1):47–51.
[31] Halamek LP, Kaegi DM, Gaba DM, et al. Time for a new paradigm in pediatric medical education: teaching neonatal resuscitation in a simulated delivery room environment. Pediatrics 2000;106(4):E45.
[32] Agency for Healthcare Research and Quality. Disseminating research results: transfer of a novel pediatric simulation program, project number HS12011–01. Available at: http://www.ahrq.gov/qual/newgrants/dissem.htm. Accessed October 17, 2006.
[33] Sullivan MJ, Guyatt GH. Simulated cardiac arrests for monitoring quality of in-hospital resuscitation. Lancet 1986;2(8507):618–20.
[34] Iirola T, Lund VE, Katila AJ, et al. Teaching hospital physicians' skills and knowledge of resuscitation algorithms are deficient. Acta Anaesthesiol Scand 2002;46(9):1150–4.
[35] Abella BS, Alvarado JP, Myklebust H, et al. Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest. JAMA 2005;293(3):305–10.
[36] DeVita MA, Schaefer J, Lutz J, et al. Improving medical emergency team (MET) performance using a novel curriculum and a computerized human patient simulator. Qual Saf Health Care 2005;14(5):326–31.
[37] Vos GD, Nissen AC, Nieman FH, et al. Comparison of interhospital pediatric intensive care transport accompanied by a referring specialist or a specialist retrieval team. Intensive Care Med 2004;30(2):302–8.
[38] Flabouris A, Runciman WB, Levings B. Incidents during out-of-hospital patient transportation. Anaesth Intensive Care 2006;34(2):228–36.
[39] Lupton BA, Pendray MR. Regionalized neonatal emergency transport. Semin Neonatol 2004;9(2):125–33.
[40] Yun S, Faraj S, Sims HP. Contingent leadership and effectiveness of trauma resuscitation teams. J Appl Psychol 2005;90(6):1288–96.
[41] Fletcher G, Flin R, McGeorge P, et al. Anaesthetists' non-technical skills (ANTS): evaluation of a behavioural marker system. Br J Anaesth 2003;90(5):580–8.
[42] Hammond J. Simulation in critical care and trauma education and training. Curr Opin Crit Care 2004;10(5):325–9.
[43] Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency department staff: does it improve clinical team performance when added to an existing didactic teamwork curriculum? Qual Saf Health Care 2004;13(6):417–21.
[44] Lee SK, Pardo M, Gaba D, et al. Trauma assessment training with a patient simulator: a prospective randomized study. J Trauma 2003;55(4):651–7.
[45] Marshall RL, Smith JS, Gorman PJ, et al. Use of a human patient simulator in the development of resident trauma management skills. J Trauma 2001;51(1):17–21.

[46] Holcomb JB, Dumire RD, Crommett JW, et al. Evaluation of trauma team performance using an advanced human patient simulator for resuscitation training. J Trauma 2002;52(6): 1078–85.

[47] Hunt EA, Hohenhaus SM, Luo X, et al. Simulation of pediatric trauma stabilization in 35 North Carolina emergency departments: identification of targets for performance improvement. Pediatrics 2006;117(3):641–8.