Simulation-based crisis resource management training for pediatric critical care medicine: A review for instructors

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Objective: **To review the essential elements of crisis resource management and provide a resource for instructors by describing how to use simulation-based training to teach crisis resource management principles in pediatric acute care contexts.**

Data Source: **A MEDLINE-based literature source.**

Outline of Review: **This review is divided into three main sections: Background, Principles of Crisis Resource Management, and Tools and Resources. The background section provides the brief history and definition of crisis resource management. The next section describes all the essential elements of crisis resource management, including leadership and followership, communication, teamwork, resource use, and situational awareness. This is followed by a review of evidence supporting the use of simulation-based crisis resource management training in health care. The last section provides the resources necessary to develop crisis resource management training using a simulation-based approach. This includes a description of how to design pediatric simulation scenarios, how to effectively debrief, and a list of potential assessment tools that instructors can use to evaluate crisis resource management performance during simulation-based training.**

Conclusion: **Crisis resource management principles form the foundation for efficient team functioning and subsequent error reduction in high-stakes environments such as acute care pediatrics. Effective instructor training is required for those programs wishing to teach these principles using simulation-based learning. Dissemination and integration of these principles into pediatric critical care practice has the potential for a tremendous impact on patient safety and outcomes. (Pediatr Crit Care Med 2011; 12:000–000)**

KEY WORDS: crisis resource management; team training; instructor; pediatric; critical care; simulation

In acute care settings, resuscitating a critically ill or injured child remains among the greatest challenges to healthcare providers. The coordinated effort of pediatric resuscitation teams is required to deliver safe and effective care and depends on complex human behaviors. The 1999 report from the Institute of Medicine (1), "To Err Is Human: Building a Safer Healthcare System," concluded that the majority of medical errors were not the result of individual actions, but rather a failure on the level of teams, systems, or processes that led to preventable mistakes. Crisis resource management (CRM) refers to a set of principles dealing with interpersonal interactions and behaviors that contribute to optimal team functioning during crises. We review the history and principles of CRM and provide resources for instructors by describing how to use simulation-based training (SBT) to teach CRM in pediatrics. We also provide an overview of several CRM assessment tools that can be used to assess CRM performance in real or simulated clinical environments.

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History

The origins of CRM lie in the aviation industry, where it came to exist under its original moniker, "crew resource management" (2). Investigations of major airline accidents identified human errors such as failures of communication, leadership, and decisionmaking as the major contributors to these accidents. This important recognition led to the incorporation of crew resource management principles in the field of aviation.

The earliest applications of CRM in clinical medicine were in anesthesia. The study by Howard et al (3) described a dedicated training course in Anesthesia Crisis Resource Management, in which a combination of didactic and SBT for anesthesiologists was applied to: "provide participants with precompiled responses to critical incidents and to instruct participants in the coordinated integration of all available resources to maximize safe patient outcomes." CRM principles have since been applied in other areas of medicine, including internal medicine (4), emergency medicine (5), pediatric critical care (6), and prehospital care (7). Most studies report the use of SBT to teach CRM principles with a common goal of training teams to function more efficiently and effectively.

Defining a Team

In the review by Baker et al (8) entitled "Medical Teamwork and Patient Safety: The Evidence-Based Relation," they defined a team as "two or more individuals with specialized knowledge and skills who perform specific roles and complete interdependent tasks to achieve a common goal or outcome." Teamwork comprises a collection of behaviors and attitudes that promotes efficient processing of information and ultimately leads to

timely and proper actions carried out by various team members. In pediatric acute care medicine, team members function in a dynamic fashion: changing roles when appropriate, prioritizing and completing tasks, and communicating effectively to minimize errors and optimize safety. CRM encompasses key behaviors that will help teams deliver coordinated and effective care to critically ill children.

Principles of Crisis Resource Management

The essential elements of team dynamics and CRM have been described in many different formats (9–11) with the overarching key principles being leadership and followership, communication, teamwork, resource use, and situational awareness.

Leadership and Followership. Pediatric resuscitation teams ideally consist of a team leader along with additional team members who have clearly assigned roles. When possible, a team leader should stand away from the bedside, maintain an overall view of the patient, and synthesize key information from team members. Team members should be competent with their role assignment and openly share information about their observations, interpretations, and interventions (3–5). Team members should be encouraged to speak up without a concern that doing so will constitute going against the authority of a team leader, a concept referred to as "flattening hierarchy" (12). Team members must not assume that the team leader has all of the pertinent information and should feel empowered to share their thoughts, particularly when their input may positively affect patient outcome.

Communication. The Joint Commission on Accreditation of Healthcare Organizations indicates that two thirds of all medical errors reported to their agency were caused primarily by a failure in communication (13). Several attributes of effective communication include: 1) assertive communication—team members command appropriate attention and deliver their message in a nonthreatening, respectful manner. This phenomenon applies to both leader-to-follower communication and follower-to-leader communication. Communicating in this fashion helps to "flatten the hierarchy," ensuring that team members will speak up if they believe something might be going wrong. Team leaders can promote this style of communication by occasionally seeking the input and thoughts of team members to help guide the management of the patient (12, 14); 2) closed-loop communication refers to a three-step process for conveying orders, in which the team leader gives a command, the team member acknowledges the command and repeats it back to the leader, and finally the team member reports when the order is completed (1, 12–14). By closing the loop with each order, team members ensure that orders are received and completed correctly, thus minimizing the risk for error during resuscitation; and 3) information-sharing and inquiry refers to an ongoing process of bidirectional (leader to member and vice versa) knowledge-sharing and corrective action when necessary. This can help to prevent inappropriate actions and the development of fixation errors in which a team cannot be easily redirected from an incorrect trajectory of care.

Teamwork (Human Resources). Optimal human resource use includes ensuring the presence and participation of enough personnel to fulfill all of the immediately necessary roles within the resuscitation team. As management of the patient progresses, new tasks will inevitably arise, and appropriate allocation of roles to qualified team members will be critical to ensure that these tasks are carried out in an efficient and correct manner.

Resource Use (Material Resources). Optimal material resource use assures that correct equipment is used optimally by designated personnel. Equipment that may be infrequently necessary should be readily available and members of the team should have enough familiarity with its use to deploy it quickly when required.

Situational Awareness. Situational awareness has been defined as "the perception of elements in the environment . . . the comprehension of their meaning, and the projection of their status into the near future" (15). It may be conceptualized as the ongoing, dynamic integration of cues from the patient, the team, and the environment and the subsequent dissemination of these cues in a global, patient-oriented context. The team as a whole should continually reassess a patient's situation and update one another to ensure that decisions are being made on current information. Terms such as "shared cognition" or "shared mental model" have been applied to this overall collective thought process (14), which can be considered as "getting everyone on the same page."

Applicability of Crisis Resource Management to Pediatric Resuscitation

Resuscitation of critically ill children has long been associated with largely poor outcomes. Resuscitations in hospitalized children occur uncommonly (16, 17), and survival outcomes from cardiac arrest are poor (18–20). Surveys of pediatric residents have demonstrated that actual patient experience in leading or participating in resuscitations is rare (21, 22). Nonetheless, the Accreditation Council for Graduate Medical Education list of required competencies for pediatric residency trainees includes "sufficient training in basic and advanced life support" without any specific provisions of how such training should be achieved (23).

In 2003, the International Liaison Committee on Resuscitation published the results of a symposium on education in resuscitation (24). Among the recommendations made for advanced life support training was that "crisis resource management and communication should be a component of advanced life support training, either as an add-on module or a separate course." The 2005 version of the Pediatric Advanced Life Support course included for the first time a section on effective resuscitation team dynamics, in which many of these principles of teamwork and communication are discussed (9).

Caring for acutely ill children often presents a unique set of circumstances, including balancing the medical needs of the patient with the emotional needs of the family or caregivers. Managing particularly challenging and stressful situations such as disruptive and intrusive parents (25), end-of-life care (26), or disclosure of bad news or medical error (27, 28) requires a specific skill set and mind set that can be taught in the context of CRM principles. Application of these skills in the simulated environment with actors serving as parents or caregivers is essential to building the confidence necessary to effectively manage critically ill children with a family-centered approach. Pediatric resuscitation represents the "perfect storm": a dangerous mix of a high-stakes environment with potential harm to the patient combined with pediatric providers who often have not had sufficient opportunity to manage critically ill children. It is in this setting in

which effective teaching of the different human and behavioral factors encompassing CRM may have a directly positive impact on patient outcomes.

Is Crisis Resource Management Training Effective?

A growing body of evidence supports the effectiveness of CRM training in improving team functioning and dynamics (10, 11, 29–33). A pediatric study by Thomas et al (11) randomized pediatric interns to the standard neonatal resuscitation program course or a modified neonatal resuscitation program course, which included team training. Those interns who took the modified neonatal resuscitation program course demonstrated more frequent information-sharing, inquiry, assertion, vigilance, and workload management. In a prospective, multicenter trial, a study by Morey et al (29) examined the effects of a Emergency Team Coordination Course on healthcare professionals by implementing pretest and posttest measurements at 4 and 8 months after training. In the group randomized to Emergency Team Coordination Course training, they found improved quality of team behaviors, improved attitudes toward teamwork, and most importantly, a significantly reduced clinical error rate in the emergency room after training. The study by Shapiro et al (30) subsequently included simulated resuscitation as an adjunct to Emergency Team Coordination Course training and found further improvement in team performance. The study by Wallin et al (31) found that students exposed to trauma team training comprised of five separate simulation scenarios had improved performance in various team skills such as leadership, interpersonal skills, distribution of workload, communication, and professional behavior. This expanding body of evidence has supported the incorporation of simulation-based training into various pediatric curricula, including programs in general pediatrics (34, 35), pediatric critical care (36), and pediatric emergency medicine (37). This begs the question, How do you effectively design simulation scenarios and structure debriefing sessions to maximize learning of CRM principles?

Simulation-Based Education for CRM Training

In SBT, healthcare teams manage simulated cases aimed at highlighting leadership, communication, and teamwork issues that arise during patient care. Training in this safe, harm-free learning environment gives pediatric healthcare providers the opportunity the practice managing both common and uncommon conditions without any risk of harm to real children. In a specialty in which true resuscitations are rare (16, 17), SBT allows pediatric healthcare providers to train to perfection, honing their skills to the point at which delivery of care is optimal even under high-risk conditions. Effective delivery of SBT is dependent on thoughtful scenario design linked to intended learning outcomes, identification of relevant CRM issues during the actual scenario, and most importantly, facilitated debriefing of the simulated resuscitation experience by a skilled instructor.

Table 1. Key Debriefing Time Points during Simulated Pediatric Resuscitation Scenarios

Time Point During Simulated Pediatric Resuscitation	Crisis Resource Management Principle
Arrival of team leader	Leadership, communication, teamwork
Arrival of parents/caregiver	Leadership, communication, teamwork, situational awareness
Arrival of consultant (e.g., intensive care unit/anesthesia)	Leadership, communication
Deterioration or change in patient condition	Leadership, communication, situational awareness, teamwork
Introduction of new information (e.g., x-rays, blood work)	Leadership, communication, situational awareness, teamwork
Performing a critical procedure (e.g., intubation, chest tube insertion)	Leadership, communication, resource use, situational awareness

Scenario Design

As an instructor, there are two approaches to designing scenarios for the purposes of teaching CRM. The first approach is based on the assumption that all simulated cases have elements of CRM inherently built into them. Even if a scenario was initially designed to teach knowledge or technical skills, running the scenario in a realistic, simulated environment with two or more team members, along with actors serving as family members, will ultimately lead to opportunities to discuss leadership, teamwork, communication, resource use, and situational awareness. Teaching with this approach is highly dependent on the instructor making accurate observations of team performance. There are key points during most scenarios in which CRM issues will inevitably arise (Table 1). Making observations during these critical points will help form the basis for discussion during the debriefing session.

The second approach involves designing the simulated scenario to incorporate particular elements of CRM. Careful scripting of the scenario and case progression, the introduction of actors as team members or family members, and/or controlling the simulated environment by providing or withholding key resources should trigger CRM behaviors (Table 2). Actors can be directed to perform certain roles specific to pediatric resuscitations such as the anxious, argumentative, or tearful parent or even medical roles such as a new junior resident or nurse, a consultant with limited pediatric experience, or a team member who is unfamiliar with pediatric-sized equipment. When choosing to adapt scenarios by withholding information or resources, instructors should ensure that scenarios are free from trickery and remain realistic to the pertinent clinical context so that students can remain immersed in the simulated scenario. Sometimes, excessive manipulation of the clinical environment can be detrimental to the learning process and disengage students from the simulation. Despite planning and scripting scenarios in a careful fashion, instructors should not assume they know exactly how teams will act or behave in all circumstances. Running simulation scenarios this way still requires attentive observation of the resuscitation to best highlight elements of CRM during the debriefing session. Table 3 outlines the

Table 2. Tips for incorporating crisis resource management elements into simulated pediatric scenarios

Crisis Resource Management Principles	Strategy to Incorporate Crisis Resource Management Principle Into the Scenario
Leadership	Wave effect[a]—introduce team members in a sequential fashion (e.g., nurses → residents → fellows)
	Introduce a new team member
	Introduce a potential new team leader (e.g., critical care physician, anesthesiologist)
	Introduce a parent or caregiver as a potential distractor
Communication	Take people out of their comfort zone (e.g., start scenario without nurses/without doctors)
	Introduce "handover," e.g., paramedic handing over to emergency team; nursing handover at shift change
	Introduce a scripted medication error
	Withhold information (e.g., relevant medical history)
	Give critical information to a team member (e.g., blood glucose) during crisis point in scenario (e.g., cardiac arrest)
	Introduce a parent or caregiver as a potential distractor
	Use phone calls
Teamwork (human resources)	Challenge team with multiple tasks/problems (e.g., hypoglycemia, seizure, hypotension, respiratory arrest)
	Wave effect[a]—introduce team members in a sequential fashion (e.g., nurses → residents → fellows)
	Introduce a junior team member (e.g., medical student)
	Introduce parents or team members who are distractors
	Introduce a team member who makes some mistakes
	Use phone calls
	Provide fewer team members
Resource use	Withhold critical equipment (e.g., defibrillator)
	Provide broken or improperly sized equipment (e.g., rupture endotracheal tube cuff)
	Provide an abundance of resources (e.g., scatter multiple endotracheal tubes on top of crash cart)
	Use a phone call to introduce the case and allow time for team to prepare for resuscitation (e.g., trauma arriving to emergency department)
Situational awareness	Design challenging scenario with more frequent physiological changes
	Design scenario history, physical or case progression to promote fixation error (e.g., cardiogenic shock from myocarditis presenting as vomiting and diarrhea)
	Challenge team leader to prioritize by providing laboratory and radiology results or introducing team members during critical points in scenario (e.g., during intubation)
	Introduce a team member who makes mistakes

[a]Wave effect is defined as the sequential introduction of team members during a simulated resuscitation. The benefit of this strategy is that each time a team member is introduced, there should be some sort of communication between new and existing team members. This strategy also provides the initial one or two providers the opportunity to manage the patient directly, often desirable for more junior learners.

pros and cons for both approaches to scenario design.

Debriefing Strategies

In the context of healthcare team performance, whether in the simulated setting or in actual clinical environments, the majority of feedback will be provided in the context of after-action reviews. These reviews, more aptly termed "debriefings" (38–41) when led by skilled debriefers, facilitate reflective practice by incorporating several key elements. A study by Simon et al (42) has outlined the elements of effective debriefings: 1) establishing and maintaining an engaging and challenging yet supportive context for learning; 2) structuring the debriefing to enhance discussion and attend to the process of reflection; 3) promoting discussion and reflective practice; 4) identifying and exploring performance gaps; and 5) helping trainees achieve and sustain good performance.

Although the specific structure used in debriefings may vary (38–40), the first phase of the debriefing is generally for reacting to the experience as well as clarifying facts and describing what happened. This step ensures that participants and facilitators agree about major events that will form the basis for later discussion. The heart of the debriefing is the middle or analysis phase, which ideally is devoted to indepth discussion of observed performance gaps (40). Of note here is that performance gaps (defined as the gap between desired and actual performance) may be incremental or decremental; in other words, better than or worse than the desired performance. Because an individual or team may perform actions for which the rationale is not immediately apparent, an effective debriefing includes an explicit discussion around the drivers that formed the basis for the gap in performance. Although actions are observable, these drivers (thoughts, beliefs, assumptions, knowledge base) are often invisible to the debriefer without skillful questioning (38–41). Indeed, inexperienced facilitators often jump to the conclusion that observed performance gaps are the result of knowledge deficits and launch into a lecture intended to remediate them. By exploring the basis for the performance gap, the debriefer can diagnose an individual's or a team's learning need and subsequently facilitate a discussion and provide focused teaching. Finally, the debriefing is concluded by having participants articulate "take-home messages" and, if needed, the debriefer summarizes key messages related to the learning objectives of the case. The process of analyzing a performance gap can be summarized in four steps: 1) identify a gap between desired and actual performance; 2) provide feedback about performance gap; 3) elicit a basis for performance gap; and 4 close the gap through discussion and teaching (40, 41).

To promote discussion and reflective practice, several approaches can be used to facilitate these processes. Although not an exhaustive list of facilitation techniques, high-yield approaches include (39–41): 1) use of a specific conversational strategy known as "advocacy inquiry." This approach allows debriefers to share their observations and own per-

Table 3. Pros and cons of two different approaches to scenario design

Approach to Scenario Design	Pros/Cons
Approach 1: no intentional incorporation of CRM triggers	Pros Lower resource requirement Lower cost Less preparation time Cons Difficult to predict which CRM issues will arise and when they will arise Requires experienced instructor to elicit CRM issues during debriefing
Approach 2: intentional incorporation of CRM triggers	Pros Easier to predict which CRM issues will arise and also when they will arise Can tailor scenarios to CRM-specific learning objectives Debriefing is easier as CRM issues are more obvious Cons Potentially higher resource requirement Potentially high cost More preparation time (i.e., development of actor scripts, etc.) Excessive manipulation of clinical environment may negatively affect degree of realism

CRM, crisis resource management.

spective on events explicitly and pair them with an inquiry (39–41). By sharing their own perspectives, debriefers make their views part of the discussion; 2) use of silence or a "pause" after a question to allow participants to process information and prepare a thoughtful response; and 3) use of video to analyze certain points of a resuscitation to highlight specific CRM behaviors. Table 2 outlines key debriefing time points which can be analyzed using video review.

Assessment of CRM Performance

To evaluate the effectiveness of CRM training, one must have the ability to measure performance. This can be done in several ways: 1) measure a process or patient-centered outcome in real patients (e.g., patient mortality, adherence to established guidelines or algorithms, timeliness of critical interventions, or rates of errors or adverse events) (43–47). This is the ideal way to assess team performance, because the ultimate goal of improving team functioning is to improve patient outcome; 2) measure a process-centered outcome in simulated patients. The study by Devita et al (48) used simulator survival as an outcome measure for team performance, in which survival of the simulator was dependent on timely completion of predetermined tasks (e.g., management of ABCD assessment, com-

Table 4. Summary of the five different assessment tools described along with measures of interrater reliability

Focus of Tool	Assessment Tool	Subjects	Crisis Resource Management Principles Addressed	Interrater Reliability
Team performance	Crisis Management Behavior Performance Markers (54)	Anesthesia physicians only	12 items encompassing Situational awareness Roles Communication Group climate	[a]Intraclass correlation coefficient 0.36–0.57 [b]r_{wg} 0.96
	Clinical Teamwork Scale (50)	Obstetrics physicians and nurses	15 items encompassing Communication Situational awareness Decisionmaking Role responsibility	[a]Intraclass correlation coefficient 0.98 [c]Kappa 0.47–0.86 [d]Kendall coefficient 0.95
	Mayo High Performance Teamwork Scale (51, 56, 57)	Multiple disciplines residents and nurses, focus on anesthesia, emergency response team	16 items encompassing Roles Communication Situational awareness Avoidance of errors	[e]Item reliability 0.96
Leader performance	Anaesthesia Non-Technical Skills System (32, 55)	Anesthesia physicians only	15 items encompassing Task management Team working Situation awareness Decisionmaking	[b]r_{wg} 0.55–0.67
	Ottawa Global Rating Scale (4, 58)	Residents from various disciplines	12 items encompassing Leadership Problem solving Situational awareness Resource use Communication	[a]Intraclass correlation coefficient 0.234–0.626

[a]Acceptable usually >0.60; [b]within-group interrater agreement statistic, acceptable usually >0.60; [c]κ value 0.6–0.8 is substantial agreement, >0.80 is excellent agreement; [d]Kendall coefficient acceptable usually >0.80; [e]item reliability acceptable usually >0.90.

pletion of definitive therapy); 3) measure team behavior using a validated, reliable tool (49–54); and 4) measure individual behavior (usually the leader) within a team environment using a validated, reliable tool (55).

The theoretical advantage of measuring team performance over individual performance is that it is quite common for the behavior for one team member to compensate for the suboptimal performance of another. Therefore, measuring the performance of one individual may not reliably reflect the overall team performance.

Assessment Tools for Measurement of Team Performance

There are several validated tools available to measure team performance. Although none of these tools were validated specifically for pediatric healthcare providers, the content and construct of the tools is applicable to assessment of CRM performance in pediatric acute care medicine.

The Crisis Management Behavior Performance Markers was developed by Gaba et al (54) for assessing anesthetists performance after participation in a CRM course. Of note, this scale was validated using simulated scenarios designed to teach only anesthetists team training concepts. Some of the 12 items in the scale are geared to the anesthetist in charge, whereas some are geared to the entire team. Unfortunately, construct validity was not assessed in this study, although the items certainly have face and content validity.

The Clinical Teamwork Scale was developed by Guise et al (50) for assessment of CRM performance for multidisciplinary obstetric teams. Construct validity was assessed by using standardized videos of team performance at varying levels of competency and then comparing raters scores with the predefined standard.

The Mayo High Performance Teamwork Scale was developed by Malec et al (51) for multidisciplinary anesthesia and emergency teams. Many different statistical analyses were conducted, which showed a high level of interrater reliability.

Assessment Tools for Measurement of Team Leader Performance

At least two tools that focus on team leader performance have been described in the literature. As mentioned, the disadvantage to this approach is that overall team performance may not reflect the performance of the leader.

The Anesthesia NonTechnical Skills System developed by Fletcher et al (55) for anesthetists. Construct validity was assessed by comparing rater scores with predefined scores from standardized videos.

The Ottawa Global Rating Scale was developed by Kim et al (4) for evaluation of leadership skills of residents participating in simulated resuscitation scenarios. Construct validity was partly assessed by demonstrating that scores of junior residents were consistently lower than those of senior residents.

CONCLUSION

In this review article, we have outlined the history and principles of CRM and provided the tools necessary to help build simulation-based CRM teaching into pediatric training programs. Effective teamwork, communication, leadership, resource use, and situational awareness during resuscitation form the foundation for efficient team functioning and subsequent error reduction in high-stakes environments. Like other domains of clinical practice, acquiring and maintaining skills in CRM require deliberate integration into pediatric residency training curricula. Dissemination and integration of these principles into pediatric critical care practice has the potential for tremendous impact on patient safety and outcomes.

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