Emergency medicine resident crisis resource management ability: a simulation-based longitudinal study

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Background: Simulation has been identified as a means of assessing resident physicians’ mastery of technical skills, but there is a lack of evidence for its utility in longitudinal assessments of residents’ non-technical clinical abilities. We evaluated the growth of crisis resource management (CRM) skills in the simulation setting using a validated tool, the Ottawa Crisis Resource Management Global Rating Scale (Ottawa GRS). We hypothesized that the Ottawa GRS would reflect progressive growth of CRM ability throughout residency.

Methods: Forty-five emergency medicine residents were tracked with annual simulation assessments between 2006 and 2011. We used mixed-methods repeated-measures regression analyses to evaluate elements of the Ottawa GRS by level of training to predict performance growth throughout a 3-year residency.

Results: Ottawa GRS scores increased over time, and the domains of leadership, problem solving, and resource utilization, in particular, were predictive of overall performance. There was a significant gain in all Ottawa GRS components between postgraduate years 1 and 2, but no significant difference in GRS performance between years 2 and 3.

Conclusions: In summary, CRM skills are progressive abilities, and simulation is a useful modality for tracking their development. Modification of this tool may be needed to assess advanced learners’ gains in performance.

Keywords: simulation; assessment; crisis resource management

The current zeitgeist in graduate medical education centers around a competency-based model that emphasizes individualized instruction and objective evidence of learning outcomes (1). In the United States, the Accreditation Council for Graduate Medical Education (ACGME) announced the current phase of the Outcomes Project, the Next Accreditation System (NAS), in February of 2012 (2, 3). The NAS directs residency programs to demonstrate trainees’ progressive mastery of knowledge, skills, and behaviors pertaining to the six core clinical competencies. In the field of emergency medicine (EM), simulation has been proposed as one of the key modalities for assessing residents’ clinical abilities within these newly framed ‘Milestones’ (4). The 2008 Society for Academic Emergency Medicine Consensus Conference on ‘The Science of Simulation in Healthcare’ held that ‘strong leadership skills are crucial to the practice of EM and thus should be a focus of team training’ (5). As the NAS is enacted, there is a growing need for evidence-based tools to evaluate trainees’ teamwork and interpersonal communication skills (6). Crisis resource management (CRM) refers to the constellation of cognitive and interpersonal communication skills that comprise effective team performance (7, 8).

Simulation has been well established as a means of assessing competency in a variety of individual clinical applications. However, limited evidence exists for the use of simulation to demonstrate growth of clinical competencies within individual learners over time. While the Ottawa GRS has been used to evaluate residents and...
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Methods
This was an observational cohort study conducted at a single academic emergency medicine residency program based in Northern California. The Institutional Review Board at the UC Davis School of Medicine approved the study. Individual resident data were de-identified prior to analysis.

The Department of Emergency Medicine at UC Davis has held annual resident simulation assessments since 2006 to augment training and to satisfy ACGME requirements in resident evaluation. Residents are tested in a single session in which each resident performs one case. Residents are scored by multiple faculty raters using the Ottawa Crisis Resource Management Global Rating Scale (Ottawa GRS), a tool developed to evaluate team leadership and communication in the simulation environment. Simulated patient scenarios were developed via an iterative process by EM faculty with expertise in simulation education and scenario development. The scenarios were targeted in complexity to postgraduate year of training and were vetted by a consensus group of EM faculty with extensive simulation experience.

One hundred and three residents trained at the UC Davis EM program during the study period, 2006–2011. The EM residency at UC Davis is a 3-year, ACGME approved program established in 1989. UC Davis residents spend 70% of their clinical education at UC Davis Medical Center (UCDMC), an urban academic Level I trauma center with an annual emergency department census of 70,000 visits per year. Residents also train at a nearby private Level II trauma center with an annual Emergency Department census of 95,000 visits per year.

We included in our analysis only residents for whom we had complete longitudinal data during the study period (i.e., all 3 years of training). Fifty-eight residents were excluded from our study: 51 residents due to training cycle (i.e., entered the study as a PGY-2 or PGY-3 or completed the study as a PGY-1 or PGY-2), four residents entered the residency program as PGY-2 or PGY-3 and did not complete the PGY-1 assessment, two residents did not participate in the simulation assessment in their PGY-3 year, and one resident left the training program after the intern year. The remaining 45 residents qualified for the analysis.

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Outcome measures
The primary outcome of interest was to measure the interval change in resident performance by PGY level for the individual components of the Ottawa GRS. The secondary outcome of interest was to determine which
elements of the Ottawa GRS were most predictive of overall performance.

Data analysis

We evaluated mean GRS scores with standard deviations and interquartile ranges by individual over time and by PGY status.

We constructed two repeated measures models to evaluate: 1) the interval significance of individual performance within a PGY class and between classes within the institution and 2) the components of the Ottawa GRS that were predictive of overall performance. The first was a mixed-effects repeated measures model that included each component of the Ottawa GRS as a candidate predictor for interval significance of an individual’s performance throughout residency. The second was a repeated-measures generalized linear mixed model, which included components of the Ottawa GRS (leadership, problem solving, situational awareness, resource utilization, communication, and overall) and interaction terms as candidate predictors of overall performance. The second model included a pooled analysis of all participants, controlling for PGY status. In each model, the clustered fixed effects were the individual (subject) effect and his or her PGY status. Specifications for the Ottawa GRS component model and the Ottawa GRS time-interval model are included in the corresponding tables. All analyses were performed using SAS software, version 9.3 (SAS Institute Inc., Cary, NC, USA; 2011).

Results

The demographics of the 45 residents are shown in Table 1. Mean GRS scores increased throughout each training year, with greater within-group variance for the PGY-1 level residents than in subsequent training years (Table 2). The greatest increase in mean GRS scores occurred between the PGY-1 and PGY-2 years (Fig. 1), despite individual variability in performance trajectory (Fig. 2).

The overall model demonstrated varying performance of individual components of the GRS (Table 3). Leadership, problem solving, and resource utilization showed statistical significance in the overall model.

Table 1. Resident participant characteristics, \( N = 45 \)

| Class graduation year | No. of participants | Male | Female | Average age | Age range |
|-----------------------|---------------------|------|--------|-------------|-----------|
| 2009                  | 11                  | 6    | 5      | 33          | 29-37     |
| 2010                  | 12                  | 8    | 4      | 32          | 29-38     |
| 2011                  | 10                  | 4    | 6      | 32          | 30-34     |
| 2012                  | 12                  | 9    | 3      | 32          | 28-41     |
| Total                 | 45                  | 27   | 18     | 32          | 28-41     |

In the longitudinal growth model, the individual components of the Ottawa GRS – as predictors of overall performance – varied in statistical significance over time (Table 4). All components were statistically significant in the interval from PGY-1 to PGY-2. In contrast, no significant difference in performance in any GRS domain in the interval from PGY-2 to PGY-3 was detected.

Discussion

In this first study to evaluate critical resource management skills over time, we found that the Ottawa GRS readily identified early growth of residents’ skills. However, the Ottawa GRS was unable to discriminate scores between higher levels of training. Early learners showed considerable variance in individual scores. As training progressed, learners’ scores clustered closer together (i.e., there was a decrease in within-group variance and increase in between-group variance). The finer differences in GRS domains were not detectable in advanced learners.

Our results should be contextualized in the step-wise evolution of the current graduate medical education evaluation paradigm. In 1999, the ACGME instituted the Outcomes Project, a multi-year residency accreditation initiative based on educational outcomes and resident performance. This project was based on six identified core competencies: patient care, medical knowledge, practice-based learning and improvement, interpersonal skills and communication, professionalism, and systems-based practice (15). The ACGME convened again in 2007–2008 to identify assessment methods for graduate medical programs. The group concluded that each specialty should adopt or develop specialty-appropriate assessment tools, termed ‘Milestones’, to encourage longitudinal assessment of residents, laying the groundwork for the NAS (16).

The EM milestones were introduced in 2012 and consist of 23 areas of core knowledge (e.g., diagnosis, pharmacotherapy), skill (e.g., vascular access, airway management), and behavior (e.g., task switching, team management) common to the practice of EM (3, 17). While documenting successful completion of procedural skills can be relatively straightforward, non-technical skills are more difficult to evaluate objectively (18).

In the field of healthcare simulation, a number of different tools have been developed to assess CRM ability, a concept which originated in the aviation industry as ‘Crew Resource Management’ and which describes the non-technical skills (e.g., leadership, situational awareness, and communication) needed to successfully coordinate the behaviors of multiple individuals engaged in complex activities (19). Gaba and Deanda adopted these principles to train anesthesiologists in critical operating room scenarios (8, 20). These concepts were quickly embraced by other specialties such as EM and critical care (21). Examples of CRM assessment instruments include the ANTS scale (Anesthesiologists’ Non-Technical
Skills), NOTECHS scale (Non-technical Skills), the OTAS (Observational Teamwork Assessment of Surgery), and the Ottawa GRS (14, 22–24). We selected the Ottawa GRS for our study because it had been rigorously validated and is straightforward and intuitive to use.

The goal of our study was to adopt a CRM assessment tool intended for discrete simulation scenarios and to use it as a ‘growth chart’ of CRM ability for individual trainees in the real-world setting of a residency program. In this novel approach, we found a statistically significant difference in performance across all components of the Ottawa GRS between PGY-1 and PGY-2 levels. However, no significant differences were found in performance on any component of the Ottawa GRS between PGY-2 and PGY-3 levels.

Our findings may be explained through the trainee’s own perspective. First-year residents come to an institution with varying backgrounds, strengths, and weaknesses. The within-group variance seen in earlier stages later diminishes, likely due to the natural course of training in the same environment. As learners ‘homogenize’ through their training, the Ottawa CRM loses discriminative ability to detect progression through domains. This is consistent with the study by Kim et al. (14) which reported that the GRS instrument had good discriminative ability when comparing PGY-1 residents to PGY-3 residents in two standardized emergency scenarios.

Our study has a number of important limitations. It was conducted at a single residency program and included a limited number of participants in a single site, affecting the generalizability of our observed results. Raters were faculty within our department and therefore not blinded to resident training level and prior clinical performance. The data were obtained over the course of multiple years by a small but variable group of faculty raters, as all raters were not present for every scenario. Individual rater data were not tracked in the database. Although interrater reliability for a particular encounter could not be evaluated, the Ottawa GRS has previously been shown to demonstrate good interrater reliability (14). While the raters did not receive extensive training in the use of the Ottawa GRS instrument, they were well versed in its rankings and appropriate use; in addition, the investigators felt the tool was sufficiently intuitive given its use of

| Component                | PGY-1 Mean | PGY-2 Mean | PGY-3 Mean |
|--------------------------|------------|------------|------------|
| Overall                  | 4.40       | 5.74       | 5.67       |
| Leadership               | 4.67       | 5.69       | 5.72       |
| Problem solving          | 4.44       | 5.65       | 5.53       |
| Situational awareness    | 4.40       | 5.61       | 5.49       |
| Resource utilization     | 4.66       | 5.72       | 5.54       |
| Communication            | 4.86       | 5.81       | 5.76       |

Fig. 1. Performance by component of the Ottawa Global Rating Scale over time.
descriptive anchors to provide a reasonably reproducible score on an individual encounter.

Other institution-specific factors likely influenced our findings. The scenarios were honed over multiple years preceding the study and were targeted to each PGY level; however, they were not originally designed specifically to evoke responses for discrete GRS domains. The relatively high mean scores of residents at all levels of training suggest a possible ceiling effect that obscures true differences in ability in the advanced stages of residency (i.e., the interval between PGY-2 and PGY-3). This leniency bias may be secondary to generational differences in the student–teacher relationship, inadequate rater training, or inherent properties of global rating scales in resident assessment (25, 26)—all features with which many programs struggle.

Finally, our study design was vulnerable to a number of confounders commonly encountered in education studies. Given the frequency with which our residents are exposed to simulation, it is possible that the gains observed in residents’ CRM ability are attributable in part to increased confidence and facility with simulation itself, rather than with the material tested. Likewise, although participants were instructed not to share details of the scenarios with each other, some degree of “contamination” between groups was unavoidable.

**Conclusions**

Our study supports the use of the Ottawa GRS to demonstrate progression of CRM ability in individual learners over the course of residency training in EM. Specifically, the Ottawa GRS instrument shows promise as a tool for charting growth early in training but may need modification for use in advanced learners. These findings may benefit the design of a future prospective, multicenter, multi-domain observational study of residents’ attainment of developmental milestones in EM.

**Fig. 2.** Profile plot of overall performance of each participant over time.

**Table 3.** Model performance using components of the Ottawa Global Rating Scale

| Component                  | F    | p       |
|----------------------------|------|---------|
| Leadership                 | 8.80 | 0.004   |
| Problem solving            | 36.48| <0.0001 |
| Situational awareness      | 0.08 | 0.8     |
| Resource utilization       | 16.21| 0.0001  |
| Communication              | 0.00 | 1.00    |

Model: overall performance = $\beta_0 + \beta_1(\text{leadership}) + \beta_2(\text{problem solving}) + \beta_3(\text{situational awareness}) + \beta_4(\text{resource utilization}) + \beta_5(\text{communication}) + \beta_6(\text{PGY status}) + \beta_7(\text{individual subject}) + \beta_8 - 12(\text{interaction terms: PGY status*individual component}) + Z_\mathbf{Y}$.

Model specifications: repeated measures generalized linear mixed models (proc glimmix); residual maximum pseudo-likelihood method; Gaussian distribution, identity link.
Table 4. Interval significance of components of the Ottawa Global Rating Scale

| Component                    | Interval from PGY-1 to PGY-2 | Interval from PGY-2 to PGY-3 |
|------------------------------|------------------------------|----------------------------|
|                              | Estimate         | SE     | t-value | p    | Estimate         | SE     | t-value | p    |
| Overall                      | -0.16            | 0.07   | -2.18   | 0.03 | 0.05             | 0.07   | 0.76    | 0.45 |
| Leadership                   | -0.21            | 0.04   | -5.71   | <0.0001 | -0.01           | 0.04   | -0.17   | 0.86 |
| Problem solving              | -0.27            | 0.05   | -5.00   | <0.0001 | 0.03            | 0.05   | 0.56    | 0.58 |
| Situational awareness        | -0.36            | 0.07   | -5.31   | <0.0001 | 0.04            | 0.07   | 0.58    | 0.56 |
| Resource utilization         | -0.44            | 0.09   | -4.86   | <0.0001 | 0.09            | 0.09   | 0.99    | 0.33 |
| Communication                | -0.90            | 0.13   | -6.78   | <0.0001 | 0.06            | 0.13   | 0.42    | 0.67 |

Model: component = β0 + β1(PGY status) + β2(individual subject) + β3(interaction term: PGY status*individual subject) + Z + ε.
Model specifications: mixed-effects repeated measures (proc mixed) by PGY status; restricted maximum likelihood method; compound symmetry covariance.

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Conflict of interest and funding

The authors report no declarations of interest.

References

1. Weinberger SE, Pereira AG, Iobst WF, Mechaber AJ, Bronze MS. Competency-based education and training in internal medicine. Ann Intern Med 2010; 153: 751–6.
2. Beeson MS, Vozenilek JA. Specialty milestones and the next accreditation system: an opportunity for the simulation community. Simul Healthc 2014; 2: 65–9.
3. Ling LJ, Beeson MS. Milestones in emergency medicine. J Acute Med 2012; 2: 65–9.
4. Emergency Medicine Milestones. Available from: http://www.cordem.org [cited 4 November 2014].
5. Fernandez R, Vozenilek JA, Hegarty CB, Motola I, Reznik M, Phrampus PE, et al. Developing expert medical teams: toward an evidence-based approach. Acad Emerg Med 2008; 15: 1025–36.
6. Nasca TJ, Philibert I, Brigham T, Flynn TC. The next GME accreditation system – rationale and benefits. N Engl J Med 2012; 366: 1051–6.
7. Cheng A, Donoghue A, Gilfoyle E, Eppich W. Simulation-based crisis resource management training for pediatric critical care medicine: a review for instructors. Pediatr Crit Care Med 2012; 13: 197–203.
8. Howard SK, Gaba DM, Fish KJ, Yang G, Sarnquist FH. Anesthesia crisis resource management training: teaching anesthesiologists to handle critical incidents. Aviat Space Environ Med 1992; 63: 763–70.
9. Clarke S, Horeczko T, Cotton D, Bair A. Heart rate, anxiety and performance of residents during a simulated critical clinical encounter: a pilot study. BMC Med Educ 2014; 14: 153.
10. Nunnink L, Foot C, Venkatesh B, Corke C, Saxena M, Lucey M, et al. High-stakes assessment of the non-technical skills of critical care trainees using simulation: feasibility, acceptability and reliability. Crit Care Resusc 2014; 16: 6–12.
11. Hicks CM, Kiss A, Bandiera GW, Denny CJ. Crisis Resources for Emergency Workers (CREW II): results of a pilot study and simulation-based crisis resource management course for emergency medicine residents. CJEM 2012; 14: 354–62.
12. Hayter MA, Bould MD, Afarsi M, Riem N, Chiu M, Boet S. Does warm-up using mental practice improve crisis resource management performance? A simulation study. Br J Anaesth 2013; 110: 299–304.
13. Kim J, Neillipowitz D, Cardinal P, Chiu M. A comparison of global rating scale and checklist scores in the validation of an evaluation tool to assess performance in the resuscitation of critically ill patients during simulated emergencies (abbreviated as ‘CRM simulator study IB’). Simul Healthc 2009; 4: 6–16.
14. Kim J, Neillipowitz D, Cardinal P, Chiu M, Clinch J. A pilot study using high-fidelity simulation to formally evaluate performance in the resuscitation of critically ill patients: The University of Ottawa Critical Care Medicine, High-Fidelity Simulation, and Crisis Resource Management I Study. Crit Care Med 2006; 34: 2167–74.
15. Swing SR. The ACGME outcome project: retrospective and prospective. Med Teach 2007; 29: 648–54.
16. Swing SR, Clyman SG, Holmboe ES, Williams RG. Advancing resident assessment in graduate medical education. J Grad Med Educ 2009; 1: 278–86.
17. Kessler CS, Leone KA. The current state of core competency assessment in emergency medicine and a future research agenda: recommendations of the working group on assessment of observable learner performance. Acad Emerg Med 2012; 19: 1354–9.
18. Chen EH, OSullivan PS, Pfennig CL, Leone K, Kessler CS. Assessing systems-based practice. Acad Emerg Med 2012; 19: 1366–71.
19. Helmrreich R. Why CRM? Empirical and theoretical bases of human factors teaching. In: Kanki B, Helmreich R, Anca J, eds. Crew resource management, 2nd ed. San Diego, CA: Elsevier; 2010, pp. 4–5.
20. Holzman RS, Cooper JB, Gaba DM, Philip JH, Small SD, Feinstein D. Anesthesia crisis resource management: real-life simulation training in operating room crises. J Clin Anesth 1995; 7: 675–87.
21. Reznik M, Smith-Coggins R, Howard S, Kiran K, Harter P, Sowb Y, et al. Emergency medicine crisis resource management (EMCRM): pilot study of a simulation-based crisis management course for emergency medicine. Acad Emerg Med 2003; 10: 386–9.
22. Fletcher G, Flin R, McGeorge P, Glavin R, Maran N, Patey R. Anaesthetists’ Non-Technical Skills (ANTS): evaluation of a behavioural marker system. Br J Anaesth 2003; 90: 580–8.
23. Steinemann S, Berg B, DiTullio A, Skinner A, Terada K, Anzelon K, et al. Assessing teamwork in the trauma bay: introduction of a modified ‘NOTECHS’ scale for trauma. Am J Surg 2012; 203: 69–75.
24. Russ S, Hull L, Rout S, Vincent C, Darzi A, Sevdalis N. Observational teamwork assessment for surgery: feasibility of clinical and nonclinical assessor calibration with short-term training. Ann Surg 2012; 255: 804–9.
25. Ringsted C, Ostergaard D, Ravn L, Pedersen JA, Berlac PA, van der Vleuten CP. A feasibility study comparing checklists and global rating forms to assess resident performance in clinical skills. Med Teach 2003; 25: 654–8.
26. Twenge JM. Generational changes and their impact in the classroom: teaching generation me. Med Educ 2009; 43: 398–405.
### Appendix A. PGY-1 Simulation Case

| Case details VF (R1) | Goals | Critical actions |
|----------------------|-------|------------------|
| 65-year-old male BIBA c/o CP for 2 h | - Identify that the CP patient is a priority patient | - Perform focused physical exam |
| ‘Feels like my first MI’ | - Rapidly assess the potentially critical patient | - Obtain 12-lead ECG |
| Onset upon waking, 10/10 | - (Medical Red) | - Place on oxygen |
| Substernal, left arm & jaw, nausea. | - Recognize ‘typical’ cardiac ischemia symptoms | - Start IVs |
| Woke up with this pain, now 5/10 | - Obtain history | - Place on monitor (including SpO2) |
| PMH: MI, DM, HTN, Chol | - Elicit drug allergies | |
| Meds: Metformin, Lipitor, Maxzide | - Get EMS report | |
| PSH: Left total knee (years ago) | - Identify as priority patient (get nursing and tech support) | |
| FSH: CAD; 40 pk yrs, married, retired | | |
| NKDA | | |
| PE: 160/90 110 20 100% on 4L NC | | |
| Awake/alert, anxious, diaphoretic | | |
| Lungs clear | | |
| Heart tachy, regular, no murmur | | |
| Perfusion good | | |
| Abdomen soft | | |
| EMS: CP protocol | | |
| Given NTG 0.4 mg SL × 3 | | |
| CP 10/10 →6/10 | | |
| BP 190/110 →150/90 | | |
| Patient refused ASA (GI upset) | | |
| 1st 12-lead: Anterior STEMI | | |
| Patient becomes unresponsive | | |
| Eyes roll back | | |
| No movement | | |
| (V. Fib on monitor) | | |
| CPR stops and patient remains in VF | | |
| No pulse | | |
| Patient is ashen and mottled | | |
| Pulse oximeter flat | | |
| Vomitus in the airway | | |
| CPR stops and SR ensues | | |
| 100/50 120 94% with bag | | |
| Patient agitated | | |
| CPR stops and patient remains in VF | | |
| Patient is ashen and mottled | | |
| Pulse oximeter flat | | |
| Vomitus in the airway | | |
| CPR stops and SR ensues | | |
| 100/50 120 94% with bag | | |
| Patient agitated | | |
| Identify pulseless arrest | | |
| Differentiate VF from stable rhythms | | |
| Assume leadership role directing ‘code’ | | |
| Recognize VF requires rapid intervention (defibrillation) | | |
| Use the correct ACLS algorithm for pulseless rhythms | | |
| Correctly administer CPR | | |
| Recognize pulseless rhythm | | |
| Recognize shockable rhythm | | |
| Recognize the need for advanced airway | | |
| Recognize ROSC | | |
| Recognize hypoxemia as dangerous in coronary ischemia | | |
| Identify cardiac ischemia/infarction | | |
| Differentiate medication intolerance from true allergy | | |
| Recognize the need for rapid intervention in ACS/STEMI | | |
| Portable CXR | | |
| Administer appropriate meds: ASA, NTG, B-blocker, morphine, heparin | | |
| Arrange Cath or thrombolitics | | |
| Reassess after interventions (pain, BP, heart rate) | | |
## Appendix B. PGY-2 Simulation Case

### Case details

**Sepsis (R2)**

| 48-year-old male presents with 3 days of cough, fever, green sputum, and 1-day dyspnea. CP is pleuritic. He has mild orthostatic symptoms. ROS negative except as above. PMH: Previously healthy, no surgeries. No Meds F/SH: Tobacco 30 pack years, EtOH – ‘a fair amount’, no illicit drug use. Married, monogamous. Travels extensively in US for work (sales). 3 school aged children – all have URIs. NKDA. PE: HR 100 BP 110/70 RR28 T 38.2 92% on RA, 100% on NRB. Awake & alert. Has accessory muscle use. Moist cough. Crackles at R base. CXR shows Right Lower Lobe Pneumonia. Sepsis = SIRS plus documented infection. Organ hypoperfusion/dysfunction – include AMS and lactate. Track urine output. Frequent VS check. | Meets SIRS criteria | Identify PNA. Order Antibiotics. Oxygen. Labs – CBC/Chem7/lactate/ABG. Fluid bolus. Sepsis = SIRS plus at least one sign of organ hypoperfusion/dysfunction – include AMS and lactate. Identify metabolic acidosis. Respiratory support intubation OK, BiPAP still OK. Initiate resuscitation with crystalloid. Notify MICU. | Pulse oximetry | Order CXR. Identify PNA. Order Appropriate antibiotics. Oxygen. Identify metabolic acidosis. Respiratory support intubation OK, BiPAP still OK. Initiate resuscitation with crystalloid. Notify MICU. |
| --- | --- | --- | --- | --- |
| 20 min later: Patient confused. VS: HR 120 BP 90/38 RR 30. SaO2 89% on RA, 97% on NRB. Labs: Na 140 K 4.5 Cl 103 HCO3-17 BUN-19 creat-1.7 glu-121, Lactate 3. WBC 20 Hct 37. | Need to recognize indication for intubation. Crystalloid fluid bolus 40-60 mL/kg (i.e., 3–5 L) Foley. Ventilate at 6–7 mL/kg. ~ 400 mL tidal volume, PEEP 5. Consider inotropic support: - Dopamine 5 mg/kg/min - Epinephrine/Norepinephrine 0.25 mg/kg/min. Transfusion to keep Hct >30% Failure to respond to fluid bolus = septic shock. | Intubate using appropriate technique. More fluid to reach 50 mL/kg bolus. Place central venous cath for vasopressors and ScvO2. Inotropic support. | Post intubation management. End scenario. |
| 40 min later: Patient very confused, not compliant. After 2 L bolus: HR 126 BP 90/32 RR 40. Sats 92% on NRB, 81% on RA. Further 2 (4 L total) HR 130 BP 85/25. Inotropic support started. Lactate 6.7. MICU busy ‘will be down soon’. Hemodynamic monitoring. | | | |
## Appendix C. PGY-3 Simulation Case

| Case details Poly trauma (R3) | Goals | Critical actions |
|-------------------------------|-------|------------------|
| 40-year-old male BIBA sp MVC hypotensive w/AMS | • Rapidly assess and address multiple potential causes of hypotension in polytrauma patient | • Obtain history |
| Had c/o of head, chest and abdominal pain. Unrestrained driver in high speed MVC. + LOC. SBP 80 at scene. PMH/PSH: unable to provide | • Recognize need for rapid intervention | • Perform focused physical exam ABCDE and address issues |
| PE: 110/70 110 30 100% on 4 L NC Somnolent, intermittently, follows commands Lungs clear, abrasion across left chest Heart-tachycardia, regular, no murmur Strong pulses Abdomen soft with mild diffuse TTP and mid abrasion Patient becomes poorly responsive and hypotensive. 90/45 | • Identify: | • Start IVs and NS bolus |
| • Closed head injury (with dec LOC) | • Reassess after initial fluid bolus | • Place on monitor (including SpO2) |
| • Small, left pneumothorax | | |
| • Hemoperitoneum with splenic rupture (per CT) | • Reassess after initial fluid bolus | |
| | • Recognize need for rapid intervention | • Appropriate prelim imaging: CXR, pelvis, FAST (+ free fluid) |
| | • Identify change | • Appropriate management of post intubation hypotension |
| | | • Appropriate management of pneumothorax in concert with intubation |
| | | • Appropriate use of blood products |
| No palpable blood pressure after intubation | • Recognize potential causes of post intubation hypotension | • Check responsiveness |
| | • Exclude esophageal intubation | • Intubate to protect airway in anticipation of transport (CT/OR) |
| | • Tension ptx | • Appropriate use of RSI (and dosing of agents) |
| | • Med effect | • Appropriate management of post intubation hypotension |
| | • Ongoing hemorrhage | • Appropriate management of pneumothorax in concert with intubation |
| VS SBP 90/p 110 Pt will require transfer to trauma center after initial stabilization of intraabdominal injuries | • Prioritize disposition | • Appropriate use of blood products |
| | | • Contact surgeon at receiving center |
| | | • Contact local surgeon for laparotomy to stabilize for transport |
| | | End scenario |
Appendix D. Ottawa Crisis Resource Management Global Rating Scale (Ottawa GRS)

**EVALUATION CRITERIA:**

This evaluation scale is directed towards assessing competence in crisis management (CM) skills and care of critically ill patients. The standard of competence has been set at the senior resident level, i.e. the third-year resident who has had prior ICU experience, and through experience as a senior housestaff physician, has previous experience in managing crises. As there exists a requisite base of medical knowledge required to effectively manage crises, this will also be evaluated. However, the focus of evaluation will be on crisis management skills. The skills listed below comprise essential aspects of crisis management. In the simulator case scenario sessions, performance in each of these areas will be assessed, in addition to the amount of prompting or guidance required during the case scenario sessions.

The following criteria will be evaluated:

**LEADERSHIP SKILLS**
- Stays calm and in control during crisis
- Prompt and firm decision-making
- Maintains global perspective ("big picture")

**SITUATIONAL AWARENESS**
- Avoids fixation error
- Resources and re-evaluates situation constantly
- Anticipates likely events

**COMMUNICATION SKILLS**
- Communicates clearly and concisely
- Uses directed verbal/non-verbal communication
- Listens to team input

**PROBLEM SOLVING**
- Organized and efficient problem solving approach (ABC's)
- Quick in implementation (Concurrent management)
- Considers alternatives during crisis

**RESOURCE UTILIZATION**
- Calls for help appropriately
- Utilizes resources at hand appropriately
- Prioritizes tasks appropriately

**OVERALL**

**Resident #:**

**Staff:**

| OVERALL PERFORMANCE | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---------------------|---|---|---|---|---|---|---|
| 1. LEADERSHIP SKILLS |  |   |   |   |   |   |   |
| Novel; all CM skills require significant improvement |  |   |   |   |   |   |   |
| Advanced novice; many CM skills require moderate improvement |  |   |   |   |   |   |   |
| Competent; most CM skills require minimal improvement |  |   |   |   |   |   |   |
| Clearly superior; few, if any CM skills that only require minor improvement |  |   |   |   |   |   |   |
| 2. PROBLEM SOLVING SKILLS |  |   |   |   |   |   |   |
| Loses calm and control for most of crisis; unable to make firm decisions; cannot maintain global perspective |  |   |   |   |   |   |   |
| Loses calm/control frequently during crisis; delays in making firm decisions (or with curing); rarely maintains global perspective |  |   |   |   |   |   |   |
| Stays calm and in control for most of crisis; makes firm decisions with little delay; usually maintains global perspective |  |   |   |   |   |   |   |
| Remains calm and in control for entire crisis; makes prompt and firm decisions without delay; always maintains global perspective |  |   |   |   |   |   |   |
| 3. SITUATIONAL AWARENESS SKILLS |  |   |   |   |   |   |   |
| Becomes fixated easily despite repeated cues; fails to re-assess and re-evaluate situation despite repeated cues; fails to anticipate likely events |  |   |   |   |   |   |   |
| Avoids fixation error only with curing; rarely reassesses and re-evaluates situation without curing; rarely anticipates likely events |  |   |   |   |   |   |   |
| Usually avoids fixation error with minimal curing; reassesses and re-evaluates situation frequently with minimal curing; usually anticipates likely events |  |   |   |   |   |   |   |
| Avoids any fixation error with curing; constantly reassesses and re-evaluates situation without curing; constantly anticipates likely events |  |   |   |   |   |   |   |
| 4. RESOURCE UTILIZATION SKILLS |  |   |   |   |   |   |   |
| Unable to use resources & staff effectively; does not prioritize tasks or ask for help when required despite cues |  |   |   |   |   |   |   |
| Able to use resources with minimal effectiveness; only prioritizes tasks or asks for help when required with cues |  |   |   |   |   |   |   |
| Able to use resources with moderate effectiveness; able to prioritize tasks and/or ask for help with minimal cues |  |   |   |   |   |   |   |
| Clearly able to utilize resources to maximal effectiveness; sets clear task priority and asks for help early with no cues |  |   |   |   |   |   |   |
| 5. COMMUNICATION SKILLS |  |   |   |   |   |   |   |
| Does not communicate with staff; does not acknowledge staff communication, never uses directed verbal/non-verbal communication |  |   |   |   |   |   |   |
| Communicates occasionally with staff, but unclear and vague; occasionally listens to but rarely interacts with staff; rarely uses directed verbal/non-verbal communication |  |   |   |   |   |   |   |
| Communicates with staff clearly and concisely most of time; listens to staff feedback; usually uses directed verbal/non-verbal communication |  |   |   |   |   |   |   |
| Communicates clearly and concisely at all times, encourages input and listens to staff feedback; consistently uses directed verbal/non-verbal communication |  |   |   |   |   |   |   |

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