Developing and Implementing a Human Patient Simulation Curriculum for Junior Medical School Students

Valeriy V. Kozmenko, MD
Kraig S. DeLanzac, MD
Jason A. Rigol, MD
Sheila W. Chauvin, Ph D
Tong Yang, MD, MS
Charles W. Hilton, MD

Anesthesiology and Intensive Care Simulation Lab
LSU School of Medicine – New Orleans

2020 Gravier St. Suite 102
New Orleans, LA 70112
vkozme@lsuhsc.edu

Abstract
We used the commercially available Human Patient Simulator – Version 6.1 (METI, Inc.) to design and implement what we believe to be one of the first curricula employing simulation for U.S. medical students. Each junior student undergoes nine sessions with the simulator learning to manage complex emergency medical problems before encountering them in the real world. This program covers simulation of the following conditions: acute thermal injury, acute upper GI bleeding, tension pneumothorax, CHF, atrial fibrillation, acute asthma attack with severe bronchial obstruction, septic shock, ARDS, and eclampsia. One session is used as an introduction to the simulation system, and the other sessions are equally spread among four major clerkships: medicine, obstetrics/gynecology, pediatrics, and surgery. Effectiveness of the sessions is assessed by administration of pre-activity and post-activity quizzes, and by grading student performance during the simulation sessions. We believe that we have successfully linked the content and learning objectives of the simulation sessions to the knowledge level of our junior medical students. The use of the simulator enhances effective retrieval and application of clinically important knowledge of complex medical conditions and facilitates the development of practical skills in patient management. This paper will present an overview of the approach that the LSU School of Medicine – New Orleans has taken in the development of this curriculum.

Introduction
Human patient simulation has been actively used in formal medical education in the medical academic world. Although the effectiveness of simulation has been appreciated subjectively by many scholars and has been confirmed objectively by several studies, at the present time human patient simulation has not been widely incorporated into medical school curricula. The Louisiana State University School of Medicine – New Orleans has developed and implemented an innovative, year-long curriculum for junior medical students using a high fidelity Human Patient Simulator (HPS) (METI, Inc.). Every third year medical student participates in eight simulation sessions equally spread among four major clerkships. In developing and implementing the simulation curriculum, there were several important issues to address:

1. organizational preparation
2. scenario content
3. learning objectives
4. session administration
5. efficacy measurement

Organizational Preparation
To effectively budget the time of the Anesthesiology and Intensive Care Simulation Lab we needed to determine:
1. number of clerkships that would send us students
2. number of simulation sessions that could be effectively delivered per day
3. number of students per session
4. structure of the curriculum so that every third year student could participate in all simulation scenarios
As soon as we began developing the course, we scheduled a meeting with the directors of four major course clerkships: medicine, surgery, pediatrics, and obstetrics/gynecology. The goal of the meeting was to ensure continuity between the future simulation curriculum and the existing clerkship curricula, as well as to define what medical conditions pertinent to each clerkship should be covered in the simulation program. Also, it was decided that each clerkship would be assigned a particular day of the week for its students to attend simulation sessions. This assignment facilitated scheduling and administration of the sessions.

To accommodate the developing third year curriculum along with the existing simulation program for the fourth year medical students rotating with Anesthesiology, we scheduled two sessions per day, each two hours long. In determining the optimal size of a group, we used our experience in working with the fourth year medical students. We believe that the optimal group size is from two to four students. This group size is large enough to provide the students with peer support, yet small enough to keep every participant active during the session. As a final result, approximately 350 simulation sessions covering eight medical conditions were scheduled, such that every medical student could participate in all eight simulation scenarios over the course of his or her third year.

Scenario Content
Determining the design and content of the simulation sessions is a complex and multifactorial process. Creating scenarios for a specific curriculum, one needs to take into account:

1. type of pathology
2. students’ level of knowledge [1], [3]
3. learning objectives of the session
4. expected critical performances of the session
5. technical capabilities of the HPS

In developing the curriculum, we decided that some of the scenarios could be interconnected rather than isolated. For example, since eclampsia may be complicated with the development of ARDS, we decided to include both scenarios into the obstetrics/gynecology block.

The medical conditions chosen were spread in the following fashion among four major clerkships:

1. Introductory session with a scenario on thermal injury, upper airway burn, and smoke inhalation.
2. Medicine
   a) Atrial fibrillation
   b) CHF
3. Pediatrics
   a) Severe bronchial asthma attack
   b) Septic shock
4. Surgery
   a) Upper GI bleeding with hemorrhagic shock
   b) Multiple trauma with tension pneumothorax
5. Obstetrics/gynecology
   a) Eclampsia
   b) ARDS

Figure 1 Students find left femur fracture during the “Multiple trauma with tension pneumothorax” scenario

It is important to have an effective introductory session prior to the beginning of the regular simulation sessions. To accomplish this, every third year medical student is sent a web link to the brief web-based introduction to the simulation lab. The web-based introduction describes what the students are expected to do in the sessions and briefly describes the functional capabilities of the HPS. Having no prior exposure to the HPS, some of the students might believe that simulation sessions are the same as small group lectures with the simulator used as a visual aid. We have told the students to approach the simulator exactly the same way they would approach a real patient. Students are instructed to discuss questions relating to patient management with their team members.
first, then use reference books and personal digital assistants (PDAs), and finally ask the instructor for help as a last resource.

During the introductory session the students receive hands-on experience working with the simulator. They assess the “patient’s” vital signs, perform endotracheal intubation, and perform CPR with feedback of the effectiveness of the chest compressions. There is also a brief scenario of thermal injury with upper airway burn and smoke inhalation included in the introductory session. Our experience demonstrates the importance of including a small interactive scenario in the introductory session. The ability of the HPS to respond physiologically and realistically facilitates the transformation of students from passive observers to active caregivers. Effective use of the interactive features of the HPS reinforces the perception that it is the simulator and not the facilitator who responds to the interventions the students perform.

**Learning Objectives**

The learning objectives, critical performance indicators, level of prior knowledge, and technical capabilities of the simulator are closely interrelated. One of the greatest features of the HPS is its level of interactivity. Unlike the other simulation systems which are predominantly procedure oriented, the HPS provides the greatest amount of interactivity in the current state of simulation development. By the third year of medical school, students have sufficient knowledge of pathophysiology, pharmacological and non-pharmacological methods of treatment, and principles of interpretation of patient response to treatment. This level of knowledge matches perfectly with the technical capabilities of the HPS. In attempting to create a bridge between this knowledge and clinical application, we put great emphasis on the sessions’ interactivity. In other words, students are expected to assess the efficacy of their treatment based on the simulated patient’s response rather than on the facilitator’s comments. The following simplified chart demonstrates the logical relationship between monitoring the patient and therapeutic decision making.

![Figure 2 Logical model of scenarios](image_url)
The following table lists the major learning objectives of each scenario.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Learning objectives</th>
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| Asthma                  | • Focused history and diagnosis  
                          • ABC, oxygen administration  
                          • β₂-agonist administration  
                          • Steroid administration  
                          • Correction of mucus rheology  
                          • Fluid administration  
                          • Interpretation of pathophysiologic changes  
                          • Drug dosage calculation                                                                                                                                  |
| Septic shock            | • Focused history and diagnosis  
                          • ABC, oxygen administration  
                          • Fluid challenge  
                          • Vasopressor administration  
                          • Antibiotic administration  
                          • Differential diagnosis with hypovolemic shock  
                          • Fluid and dopamine resistance recognition and interpretation  
                          • Prediction of developing possible complications  
                          • Drug dosage calculation                                                                                                                                  |
| Atrial fibrillation     | • Focused history and diagnosis  
                          • ABC, oxygen administration  
                          • ECG interpretation  
                          • Ventricular rate control  
                          • Anticoagulation and control of its effectiveness  
                          • Rate control  
                          • Rhythm maintenance  
                          • Recognition of possible complications (pulmonary embolism, ischemic stroke)  
                          • Recommendations to the patient                                                                                                                              |
| CHF                     | • Focused history and diagnosis  
                          • ABC, oxygen administration  
                          • Right-sided vs. left-sided heart failure                                                                                                                  |
| Upper GI bleeding and hemorrhagic shock | • Focused history and diagnosis  
                          • ABC, oxygen administration  
                          • Airway protection and prevention of aspiration  
                          • Estimated blood volume loss  
                          • Fluid replacement rate and volume  
                          • Composition of fluid replacement therapy (crystalloids, colloids, blood products)  
                          • Choice of vasopressor and its rate of administration  
                          • Possible complications and interventions                                                                                                                      |
| Multiple trauma and tension pneumothorax | • Focused history and diagnosis  
                          • ABC, oxygen administration  
                          • Monitoring the vital signs  
                          • Tension pneumothorax recognition  
                          • Tension pneumothorax decompression  
                          • Correction of traumatic and hemorrhagic shocks  
                          • Possible complications and interventions                                                                                                                   |
| Eclampsia               | • Focused history and diagnosis  
                          • ABC  
                          • Dosage of magnesium sulfate and convulsion control  
                          • Clinically assessing the effectiveness of convulsion control  
                          • Recognition and correction                                                                                                                                     |
of magnesium toxicity
• Hypertension control
• Possible complications during and after delivery

| ARDS in obstetric practice | • Focused history and diagnosis  
|                           | • ABC, oxygen administration  
|                           | • Differential diagnosis with cardiogenic pulmonary edema  
|                           | • Endotracheal intubation and mechanical ventilation  
|                           | • Ventilator parameter settings  
|                           | • Parenteral feeding |

Table 1 Learning objectives of the scenarios that comprise the junior medical school simulation curriculum

**Session Administration**

The LSU School of Medicine is in a unique position in terms of effective delivery of simulated sessions to its medical students because it owns a state of the art Health Science Center building of approximately 2,500 square feet. This facility houses two full-size operating rooms designated for simulation, two practical skills labs, eight small session rooms fully equipped with high-speed Internet access, and a lecture hall.

Each session begins with a written case presentation that describes the patient’s medical background and medication history. After that, the students are reminded that they are physicians and that they are responsible for making decisions to treat the patient. In most of the cases, the facilitator tells them, “I will help you with the treatment of this patient, but whenever you want me to do something, be as precise as possible.” For example, in the hemorrhagic shock scenario, an order of “two large bore IVs wide open” will not be accepted. The students must not only order two large bore IVs but must also specify the type of IV fluid and the rate of administration.

To reinforce correct decision making in patient management, students are challenged to verbalize the rationale behind any decision they make. This usually triggers discussion among the team members with recollection of pathophysiological and pharmacologic concepts important to the case, thereby facilitating peer-to-peer teaching and teamwork. Often, when students approach a critical learning objective and make a correct decision, emphasis is placed on this learning objective by increasing the stress level. For example, when the students decide to administer a glucocorticoid in the bronchial asthma case, the facilitator may assume the role of a child’s parent who resents hormone administration unless it is proven to him to be necessary [2] have found this approach to be very effective because it initiates another cause-effect reasoning loop (see Figure 1) and forces the students to verbalize all their decision-making steps. Thus, the students are performing the same scenario several times: once actually performing it, and several more times “replaying” the scenario when they verbalize their decision-making steps.

At the end of simulation session, there is a short debriefing during which the students are asked to narrate the patient’s medical history, physical findings, and the major components of that patient’s treatment. The session ends with the students taking the same ten multiple choice question quiz. The results of the quizzes are kept in a database for analyses of the effectiveness of the simulation sessions.

**Efficacy Measurement**

For each simulation session, students take both pre-activity and post-activity quizzes to assess how well the learning objectives are achieved in the session [4]. The same quiz of ten multiple choice questions is given both before and after the session. The quizzes also help the students to focus on the key points of the session.

During the period from the first of July till the first of September, there were one hundred and thirty eight pre-activity and post-activity paired scores obtained for four of eight simulation scenarios. The very first simulation session in each rotation has been devoted to the introduction, and the introduction has not been scored. The results of preliminary statistical analysis and pre/post-test hypothesis testing are encouraging and support learning effectiveness of interactive simulation-based teaching/learning for the targeted clinical emergencies (N=138, p<0.0001).

**Conclusion**

Developing a simulation curriculum for medical school students is a complex and multifactorial process. It requires organizational preparation in coordination with existing curricula, identification of scenario content appropriate for students’ knowledge level and the simulation system’s technical capabilities, identification of learning objectives for each scenario, promotion of interactive learning in the administration of sessions, and the development of tools to measure the effectiveness of these sessions. Additionally, effective administration of each session requires a facilitator with good communicational skills and adequate knowledge of basic science and clinical concepts.
The LSU School of Medicine – New Orleans has developed a Human Patient Simulation curriculum for its junior medical students, and our preliminary statistical analysis shows effectiveness of the simulated sessions as an interactive tool in clinical bed-side teaching.

References

