*American Journal of Pharmaceutical Education* **2007; 71 (3) Article 48.**

# INNOVATIONS IN TEACHING

## Simulation-Based Learning to Teach Blood Pressure Assessment to Doctor of Pharmacy Students

Amy L. Seybert, PharmD,[a] and Christine M. Barton[b]

[a]School of Pharmacy, University of Pittsburgh
[b]Peter M. Winter Institute for Simulation, Education, and Research, Pittsburgh, Penn

Submitted November 6, 2006; accepted January 6, 2007; published June 15, 2007.

**Objective.** To assess the effect of simulation-based learning on doctor of pharmacy (PharmD) students' ability to perform accurate blood pressure assessments and to measure student satisfaction with this novel teaching method.
**Methods.** Didactic lectures on blood pressure assessment were combined with practical sessions using a high-fidelity computerized patient simulator. Before and after the simulation sessions, students completed a written objective examination to assess knowledge and completed a survey instrument to determine their attitudes regarding the learning experience. Individual clinical skills were assessed using the patient simulator.
**Results.** Ninety-five students completed the study. Significant improvement was seen in students' knowledge and their ability to accurately determine blood pressure following simulation sessions. Survey responses indicated that students felt confident that simulation-based learning would improve their ability to perform accurate blood pressure assessments.
**Conclusion.** Pharmacy students showed significant improvement in clinical skills performance and in their knowledge of the pharmacotherapy of hypertension. Students expressed high levels of satisfaction with this type of learning experience.
**Keywords:** patient simulation, cardiovascular disease, hypertension, blood pressure

## INTRODUCTION

Cardiovascular disease remains the leading cause of mortality in the United States. In 2003, the American Heart Association reported that over 65 million Americans have high blood pressure.[1] Nearly 2,500 Americans die of cardiovascular disease each day. Pharmacists can improve the care of patients with cardiovascular disease, including hypertension,[2-6] and pharmacist involvement improves not only clinical outcomes but economic outcomes as well.[7-9] Thus, colleges and schools of pharmacy are challenged with preparing students to perform appropriate intervention activities, such as blood pressure monitoring, patient counseling on antihypertensive medications, and pharmacotherapeutic recommendations for the management of hypertension. The standard of education to this point has been to provide structured didactic lectures, patient case scenarios, problem-based learning (PBL) techniques, and clinical assessment laboratories to teach the fundamentals of blood pressure assessment and management of hypertension.

Studies have evaluated training and assessment programs involving simulation of patients with hypertension using either live actors or clinical preceptors.[10,11] The inherent problem with training programs for blood pressure measurement is the inability to objectively verify the accuracy of each reading. When using human patients or actors, there is no way to verify that the blood pressure measurement the student obtains is accurate since a reading taken by an instructor just minutes later could reflect either an error in the student's reading or simply the normal fluctuation in blood pressure that humans experience. The assessment technique is relatively simple to perform, but the ultimate goal for the students is to obtain accurate readings each time they perform blood pressure measurement. An innovative approach to ensure accuracy of measurements is the use of programmable computerized patient simulators. Patient simulation provides a precisely controlled environment where the instructor can adjust the simulator's blood pressure and other vital signs to

**Corresponding Author:** Amy L. Seybert, PharmD. Address: University of Pittsburgh Medical Center, 302 Scaife Hall, 200 Lothrop St., Pittsburgh, PA 15213. Tel: 412/647-6170. Fax: 412/647-5847. E-mail: seyberta@upmc.edu.

exact numbers. Some patient simulators even allow the instructor to view the rate at which the student is deflating the blood pressure cuff.

Patient simulation in medical education has been established in medical and nursing schools throughout the United States. Simulation-based learning (SBL) has been utilized in many disciplines, including anesthesiology,[12,13] cardiology,[14] obstetrics,[15] emergency medicine,[16,17] critical care medicine,[18] team training,[19,20] emergency preparedness,[21] pediatrics,[22] nursing,[23,24] and pharmacy.[25] The recommendations from the panel on General Professional Education of the Physician of the Association of American Medical Colleges and the subsequent Edinburgh Declaration supported a shift in medical education from large classroom instruction to interactive, competency-based learning.[26,27] SBL represents one way of complying with these recommendations.

The purpose of this prospective trial was to assess the use of SBL on students' ability to perform accurate blood pressure assessments and to complete objective written examinations of hypertension therapy. Student satisfaction with this novel teaching method was also measured.

## METHODS

SBL opportunities for pharmacy students were developed and investigated by the University of Pittsburgh School of Pharmacy.[25] The patient simulator is located at the Peter M. Winter Institute for Simulation, Education, and Research (WISER) Institute, a state-of-the-art center for simulation education and research. The mannequins are controlled by Sim-Man (Laerdal Corporation, Stavanger, Norway) computer program and can be programmed to have palpable pulses, audible heart, lung, and abdominal sounds, visible hemodynamic parameters (including continuous electrocardiogram) on a monitor, and visible blood pressure cuff deflation rates. The facilitator can program the software for any blood pressure by simply entering it on the control screen. These patient simulation models also have the capability to respond by speaking. This study was approved by the Institutional Review Board of the University of Pittsburgh.

Use of a patient simulator for hands on experience in accurately measuring blood pressure was incorporated into the pharmacy curriculum of the University of Pittsburgh School of Pharmacy. *The Pharmacotherapy of Cardiovascular Disease*, a required course in the second-professional year, combines didactic lecturing, case presentations, small group practicals, small group literature evaluation presentations, active learning, and simulation education/evaluation. A patient simulator from the WISER Institute was brought to the classroom immediately after the didactic lecture on assessment of blood pressure and again 2 weeks after this initial practice session.

Prior to classroom practice sessions with the patient simulator, students were presented with the blood pressure grading rubric (Appendix 1) utilized to standardize assessment of student performance. Each student group, comprised of an average of 6 students, participated in one 15-minute simulation session with the human patient simulator in the large classroom setting. Each group was oriented to the capabilities of the mannequin. Two facilitators controlled the simulation for each group, with one facilitator programming the mannequin and the other facilitator at the bedside guiding students and assessing student competence. Figure 1 shows the facilitator in the simulation room providing feedback to the students. The Sim-Man software was programmed with 10 different vital signs; parameters were adjusted prior to each student's attempt to obtain a blood pressure assessment. The simulation software allows the facilitator to preprogram blood pressures to change over time or to simply enter a blood pressure on the control panel. The facilitator responsible for programming the simulator provided immediate verbal feedback to each individual student in addition to completing the grading rubric. Also, the facilitator could monitor the rate of cuff deflation via a real-time adjusting bar graph on the computer screen and see the exact numeric value of the blood pressure.

At the end of the semester, each student group was assigned a 1-hour simulation session at the WISER Center for a final practical skills evaluation. During this session, each student's ability to obtain appropriate blood pressure and pulse assessments was graded for a total of 10% of their final grade for the practical sessions of the course.

Students were given a written objective examination prior to and after the hypertension section of the course to assess knowledge of blood pressure assessment. This examination was anonymous and for study purposes only. All students were evaluated by our traditional methods for the course grade, including written examinations and clinical performance assessment during all practical sessions throughout the course.

Students also completed an anonymous presimulation and postsimulation survey instrument. Each student randomly selected a code for use on both survey instruments so that changes could be assessed while maintaining anonymity. The survey instruments consisted of 4 questions that assessed students' attitudes toward their ability to accurately perform blood pressure assessment. Responses were based on a Likert scale on which 1 = poor or strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = excellent or strongly agree.[28,29] On the postsimulation survey instrument,

Figure 1. The facilitator discusses pharmacy students' performance immediately after their participation in a simulation-based learning session using a patient mannequin.

students were also asked what they liked most about this experience, what they liked least, and for any additional written comments they would like to make.

A chi-square test was used for categorical data and analysis of variance (ANOVA) was used for assessment of rubric scores.

## RESULTS

Descriptive statistics of the students in the *Pharmacotherapy of Cardiovascular Disease* course are shown in Table 1. One hundred two students completed the patient simulation sessions and 95 (93%) completed the written examinations and survey instruments. Seven students did not complete the anonymous examination and survey instrument, as this was not a requirement of the course. Students' blood pressure measurement skills showed significant improvement after each practice session with the patient simulator (Table 2) and also in posttest scores taken after the final session at the WISER Institute (Table 3). Survey results indicated that students had a positive attitude towards SBL even before they had any experience with this type of learning (Figure 2). Students were confident that patient simulation would improve their ability to measure blood pressure and their opinion changed little after the sessions (presimulation = 4.3 vs. postsimulation = 4.4; $p$ value $>0.05$).

Table 1. Descriptive Statistics of Second-Professional Year Pharmacy Students Enrolled in a Course Using Simulation-based Learning to Teach Blood Pressure Assessment, N = 102

| Demographic | No. |
|---|---|
| Gender | |
| Males | 40 |
| Females | 62 |
| Average age (years) | 21 |
| Race | |
| Caucasian | 95 |
| Asian | 6 |
| African American | 1 |
| Students with prior degrees | 8 |

Student comments were extremely positive regarding the use of SBL throughout the course. Students perceived an advantage to learning on virtual patients with the use of the high-fidelity mannequins in comparison to learning on actual patients. Some comments stated that this learning environment improved their confidence and provided a safe learning environment where they were not frustrating the patients on whom they were learning. The overwhelming response throughout the class was that this teaching method should be used throughout the curriculum and that it provided the knowledge and practice that is warranted for training pharmacists.

## DISCUSSION

SBL utilizing patient simulators is an innovative and novel approach to pharmacy education, providing students with an opportunity to participate in making assessments for ''patients'' in a safe, non-threatening environment that closely resembles an actual patient care setting. An important advantage is the ability for students in the early learning phase of their education to repeat the experience as many times as necessary to achieve competence without involving actual patients. In addition, critical clinical situations can be simulated to offer a complexity that parallels real life situations.

We have shown that SBL can improve knowledge as well as pharmacy students' performance of blood pressure assessment. Performance measurements can quickly and accurately be assessed utilizing high fidelity

Table 2. Assessment of Pharmacy Students' Ability to Perform Accurate Blood Pressure Measurements

| Assessment | First Session | Second Session | Final Session | $P^{\dagger}$ |
|---|---|---|---|---|
| Average score from grading rubric (highest possible total score = 8) | 4.2 | 5.8 | 7.8 | 0.029 |
| Students obtaining accurate blood pressure* | 21.5% | 65.6% | 97.6% | <0.05 |

*Accurate blood pressure was defined as a reading within 5 mm Hg of the programmed blood pressure
†Difference between first and final session

simulators. Students respond in a positive way to this type of innovative and interactive learning.

Schools of pharmacy have been using teaching techniques such as computerized simulations, actor simulations, case discussions, PBL, and experiential learning, in addition to didactic lecturing, for years. With advancements in technology, there are many other potential methods for teaching and learning, including SBL and other forms of virtual reality simulations. Other healthcare professions have demonstrated significant success with the use of SBL at several levels of education, including classroom instruction, clinical performance skills, and team performance training. There is support for SBL as a superior option compared to other forms of learning including PBL. Steadman and colleagues reported that fourth-year medical students undergoing SBL performed better on final assessment examinations and showed greater overall improvement in scores than students undergoing PBL.[30] This confirms that "hands-on" SBL in a controlled setting better prepares students for "real-world" practice than do traditional methods of teaching.

The University of Pittsburgh School of Pharmacy is dedicated to advancing the quality of education with innovative strategies. Based on the positive experience with SBL in teaching blood pressure assessments at our institution, we are expanding the use of SBL into other areas of cardiovascular pharmacotherapy, such as dysrhythmia management, myocardial infarction, and heart failure. We are also utilizing SBL in advanced experiential learning rotations. Other potential uses for this simulation tool include assessing students' communication skills during patient interactions or during interactions with other health care professionals. This tool may also provide excellent continuing education opportunities for pharmacists who are required to respond to patient care emergencies in institutional settings.

In order to utilize simulation education via patient mannequins, technically advanced skills will be needed to incorporate this mode of learning into the curriculum. Faculty members could partner with existing simulation training centers, medical schools, nursing schools, or other training facilities to replicate this educational technique. Advanced training in patient case design, case simulation development, debriefing tool preparation, and objective assessments techniques will be vital.

## CONCLUSIONS

In this study, pharmacy students showed significant improvement in clinical skills performance of blood pressure assessment and knowledge of the pharmacotherapy of hypertension as demonstrated by test scores. This method of teaching resulted in high levels of student satisfaction as well as increased competence. Introducing

Table 3. Presimulation and Postsimulation Examination on Blood Pressure Assessment, N = 95

| Question | % of Students With Correct Answer Presimulation | % of Students With Correct Answer Postsimulation | *P* |
|---|---|---|---|
| How many minutes should a patient rest in a sitting position before performing a blood pressure assessment? | 53.8 | 95.9 | <0.05 |
| What foods or drinks may affect a patient's blood pressure assessment? | 84.0 | 97.9 | 0.001 |
| How do you determine maximum inflation level for a patient? | 14.3 | 96.8 | <0.05 |
| At what rate should the cuff be deflated when listening for the systolic and diastolic blood pressure? | 46.1 | 95.8 | <0.05 |
| The first sound heard when deflating the cuff is the diastolic pressure and the last sound heard is the systolic blood pressure. (True/False) | 88.3 | 97.9 | 0.009 |

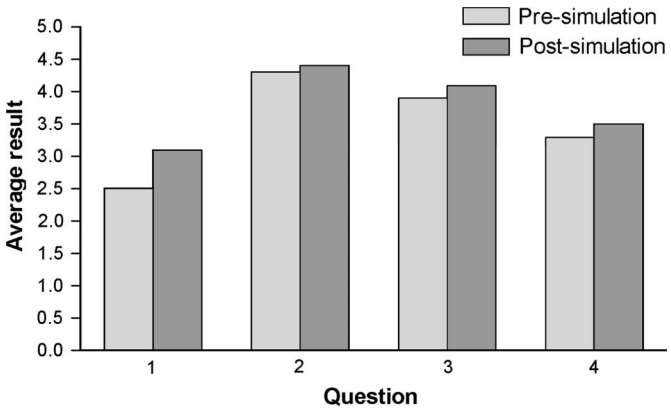


Figure 2. Presimulation and postsimulation survey results of students participating in simulation-based learning using a patient mannequin. (Question 1: How confident are you in your ability to perform a blood pressure assessment? Question 2: Do you feel that patient simulation of blood pressure monitoring will increase your ability to perform a blood pressure assessment on a patient? Question 3: Do you feel that it is a pharmacist's responsibility to perform blood pressure assessments for their patients? Question 4: Do you feel that a didactic lecture on measuring blood pressure will improve your ability to perform a blood pressure assessment?)

"real-life" clinical scenarios early in the pharmacy curriculum using patient mannequins and SBL can lead to an improvement in overall patient care, which is our ultimate goal as pharmacists.

## ACKNOWLEDGEMENTS

We would like to acknowledge the WISER Institute for the support and use of the patient simulators. We would also like to thank Teresa McKaveney for her editorial assistance.

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Appendix 1. Blood Pressure Assessment Grading Rubric

**BLOOD PRESSURE EVALUATION**
**ASSESSMENT OF STUDENT PERFORMANCE**
**Pharmacotherapy of Cardiovascular Disease PHARM 5216**

Student Name (Print): _____Evaluator Name (Print): _____

Evaluation Date: _____ **EVALUATOR SIGNATURE:** _____

| **Patient Assessment: ITEM 1: Position of the Patient** | | |
|---|---|---|
| Competent | Assures that Patient is sitting straight in chair, legs not crossed, feet flat on the floor | |
| Unacceptable | Does not advise Patient of proper position for BP measurement | |

| **Patient Assessment: ITEM 2: Application of cuff** | | |
|---|---|---|
| Outstanding | Determines correct size; centers cuff bladder over brachial artery; places lower edge of cuff 1" above the elbow crease; wraps cuff smoothly and snugly | |
| Competent | Centers cuff bladder over brachial artery; places lower edge of cuff 1" above the elbow crease; wraps cuff smoothly and snugly | |
| Unacceptable | Does not meet *competent* criteria | |

| **Patient Assessment: ITEM 3: Determine maximum inflation level** | | |
|---|---|---|
| Competent | While palpating radial pulse, observes sphygmomanometer and inflates cuff smoothly until pulse is no longer felt; deflates cuff and adds 30 mm Hg to the reading at which point pulse was obliterated | |
| Unacceptable | Does not determine maximal level of inflation | |

| **Patient Assessment: ITEM 4: Palpate the brachial artery** | | |
|---|---|---|
| Competent | Able to palpate brachial artery between anterior and medial aspects of arm | |
| Unacceptable | Inflates cuff without palpating brachial artery | |

| **Patient Assessment: ITEM 5: Applies stethoscope over brachial artery** | | |
|---|---|---|
| Outstanding | Places bell (AHA) or diaphragm of stethoscope over brachial artery with firm seal, but lightly enough to avoid constricting the artery; applies bell/diaphragm just below but not touching cuff | |
| Competent | Places bell (AHA) or diaphragm of stethoscope over brachial artery with firm seal, but lightly enough to avoid constricting the artery; bell/diaphragm not placed appropriately with respect to edge of cuff | |
| Unacceptable | Does not place bell or diaphragm over brachial artery (at site of palpation of artery) | |

| **Patient Assessment: ITEM 6: Inflate cuff** | | |
|---|---|---|
| Outstanding | Should be no more than 3 feet from sphygmomanometer gauge; gage viewed from proper position and angle; inflate cuff at smooth continuous rate over 7 - 10 seconds to previously determined maximum inflation pressure | |
| Competent | Inflates cuff at smooth, continuous rate to previously determined maximum inflation pressure | |
| Unacceptable | Does not inflate cuff smoothly to previously determined maximum inflation pressure | |

| **Patient Assessment: ITEM 7: Deflate cuff** | | |
|---|---|---|
| Outstanding | Opens thumb valve slightly, and maintaining a constant rate of deflation at approximately 2mm per second, allows cuff to deflate, listening through entire range of deflation until 10 mm below level of diastolic reading, then fully deflates cuff by opening thumb valve | |
| Competent | Opens thumb valve slightly, allows cuff to deflate, listening through entire range of deflation until 10 mm below level of diastolic reading, then fully deflate cuff by opening thumb valve | |
| Unacceptable | Releases thumb valve at more than 10 mm Hg below level of diastolic reading, or listens through entire range of deflation down to 0 | |

**Must have all 7 items at competent or outstanding in order to achieve success*