Simulation-Based Learning Versus Problem-Based Learning in an Acute Care Pharmacotherapy Course

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Introduction: There is a lack of comparative data with simulation-based learning (SBL) and other types of learning. The objective of the study was to determine whether high-fidelity simulation is superior to problem-based learning (PBL) for training pharmacy students in an acute care elective.

Methods: Twenty-nine pharmacy students enrolled in the Acute Care Pharmacotherapy Simulation course over 2 years voluntarily participated in this randomized, crossover study. Students were randomized to group 1 or 2. The SBL group consisted of students in group 1 who had SBL during study week 1 and group 2 students who had SBL in week 2. The PBL group consisted of students in group 1 who had PBL cases during study week 2 and group 2 students who had PBL cases in week 1. The topics covered were management of dysrhythmias [week 1] and heart failure [week 2].

Results: The SBL group significantly improved compared with the PBL on postquiz scores. The SBL group performed at least 15% better in the clinical assessment (P = 0.013). Students in the SBL group performed significantly better in their critical thinking skills for problem list, pharmacotherapy plan, and monitoring plan.

Conclusions: Learning was enhanced with the use of SBL compared with PBL.

Key Words: Patient simulation, Simulation-based learning, Problem-based learning.

Over the past 5 years, there has been a growing body of evidence supporting the use of simulation-based education within the pharmacy curriculum, but few data exist to compare this teaching modality to other types of learning. Other health care disciplines adopted the use of simulation several years ago, and pharmacy has recently adopted the use of simulation as equivalent experience for 20% of introductory pharmacy practice experiences.

Problem-based learning (PBL) has been a pedagogy that many pharmacy, medical, and nursing programs use at various stages and levels within their curricula. One of the impetuses for PBL was the demand for development of critical thinking and problem solving skills. Problem-based learning has been used within our doctor of pharmacy program for more than 6 years, and both our faculty and students are familiar with the necessary components of this type of learning. The PBL sessions within our curriculum involve challenging cases where the students learn from one another, leading questions, their own research of the issues identified in the case, and their individual existing knowledge. The facilitator serves as a guide in learning to support the process.

A more contemporary learning environment to enhance critical thinking and problem solving skills, in addition to physical assessment skills, has been simulation-based learning (SBL) with high-fidelity human patient simulators (HPSs). Simulation-based learning provides the students with the type of hands-on experience that is similar to a real-life clinical setting. Simulation encounters are considered to be the time that the student spends managing the “patient.” We have used high-fidelity human simulation in our pharmacy curriculum for more than 9 years for various courses because it is integrated across our PharmD curriculum.

Steadman et al. found that simulation-based training provided improved acquisition of assessment and management skills compared with PBL in medical students. The objective of our study was to determine whether high-fidelity simulation is superior to PBL for the training of third-year pharmacy students in an acute care elective.

METHODS

All 29 pharmacy students enrolled in the Acute Care Pharmacotherapy Simulation course over 2 years (2008 and 2010) were asked to voluntarily participate in this randomized, crossover study. Institutional review board approval was obtained before commencement of this study. After an orientation and initial assessment (quiz), students were randomized to group 1 or 2. Group 1 participated in HPS during study week 1 and in PBL during week 2. Group 2 participated in PBL during week 1 and HPS during study week 2.
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in the learning environment, and student-elicited feedback
were asked to assess pharmacotherapeutic options and rec-
ure, new-onset atrial fibrillation, and diabetes. Students
had experienced at least 6 similar simulation cases before
this study. Therefore, each group was equally familiar with
simulation.

SBL Sessions
Simulation sessions were conducted at the Peter M.
Winter Institute for Simulation Education and Research.
Simulation encounters were held in medical education the-
aters that have the functionality and appearance of actual
patient rooms. The HPS used was SimMan (a high-fidelity
HPS manufactured by Laerdal Medical). Each encounter
allowed groups of 6 to 7 students to be briefed on the current
condition of the patient. This information allowed the group
to provide a diagnosis and then recommend pharmacologic
treatment. All students had used simulation education in 2
required courses within our curriculum before this course and
had experienced at least 6 similar simulation cases before
this study. Therefore, each group was equally familiar with
simulation.

Description of Educational Content for SBL and PBL Sessions
The topics covered during this interventional period were the management of dysrhythmias (study week 1) and a
case on the management of heart failure (study week 2). These cases were obtained from a book of published phar-
macotherapy cases.20,21 The patient with dysrhythmia20 was a
51-year-old man with a history of hypertension and 2 acute episodes of crushing chest pain that radiated down
his left arm. The patient requires defibrillation and has an anterior wall myocardial infarction and heart failure. In addition, the patient undergoes percutaneous coronary in-
tervention with stent placement necessitating recommenda-
tions for acute therapy. Students are asked to weigh the
therapeutic alternatives for treatment of acute-onset ven-
tricular tachycardia and select the optimal drug and regimen
for this patient including chronic therapy. The patient with
heart failure21 was a 65-year-old man who was brought to
the emergency department with shortness of breath and
diaphoresis after attempting to climb a flight of stairs. The
patient has additional symptoms of acute-onset heart fail-
ure, new-onset atrial fibrillation, and diabetes. Students
were asked to assess pharmacotherapeutic options and rec-
ommend acute and chronic therapies.

The learning objectives, materials covered, cases, time
in the learning environment, and student-elicited feedback
were identical for both modalities. All students had the same content and equal amount of educational time in
each learning environment. All students had SBL for the
previous and remaining topics covered in this course.

All students before the chronic heart failure (CHF) and
dysrhythmia cases were required to assess their baseline
knowledge. The same quiz was repeated at the end of the
interventional cases for all students to determine additional
knowledge gained. The quiz contained multiple-choice ques-
tions and case-based short-answer questions. In addition to
the postintervention quiz, all students also underwent an
individual clinical assessment immediately after both the PBL
and the SBL sessions using an applicable patient case that
was simulated with a high-fidelity mannequin. Three simu-
lation rooms with 3 different instructors conducted the clin-
cal assessments, and all instructors had the same level of
simulation experience. The clinical assessments were graded
using an objective pharmacotherapy rubric that has been
previously published.2 The rubric contains 6 key com-
ponents for evaluation: (1) introduction to the patient, (2) data
collection and interpretations, (3) patient problem list, (4)
pharmacotherapy plan, (5) monitoring, and (6) verbal com-
munication. This clinical assessment using a pharmacother-
apy rubric is used in this course for midterm and final
examinations. The students randomly entered the simulation
rooms as the room became available. The quizzes contained
an anonymous identifier that did not reveal the student’s
identity or group assignment until after scoring was com-
plete. Lastly, the students completed a subjective assessment
of which teaching method they preferred and which teaching
method they felt was more suited to assist them with patient
care and increased confidence.

When analyzing the data, students who completed the
SBL session for dysrhythmia or CHF case were combined
and considered the SBL group for analysis. Students who
completed the PBL session for dysrhythmia or CHF case
were combined and considered the PBL group for analysis.
We used student t tests to determine the differences be-
tween preintervention and postintervention scores on the
quizzes and clinical assessments. Significance level was set
to a P < 0.05.

RESULTS
As seen in Table 1, students did not have significantly
different scores for the prequiz period, indicating that they
had a similar baseline knowledge base. The SBL group
significantly improved compared with the PBL for their
postquiz scores (P = 0.013). The SBL group preformed
at least 15% better in the clinical assessment that was
significant (P < 0.001). Students in the SBL group all

Table 1. Comparison of Quiz and Clinical Assessment Scores

<table>
<thead>
<tr>
<th>Grade Assessment</th>
<th>Average ± SD for SBL Sessions (%</th>
<th>Average ± SD for PBL Sessions (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prequiz score</td>
<td>49.4 ± 19</td>
<td>51.2 ± 17.8</td>
<td>0.704</td>
</tr>
<tr>
<td>Postquiz score</td>
<td>68.7 ± 13</td>
<td>59.3 ± 14</td>
<td>0.013</td>
</tr>
<tr>
<td>Clinical assessment score</td>
<td>78.8 ± 9.4</td>
<td>63.1 ± 10</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

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performed significantly better for the clinical assessment in the problem list, pharmacotherapy plan, and monitoring components of the rubric (P < 0.05; Fig. 1). The average performance score for the heart failure case was 63.4%, and the average performance score for the dysrhythmia case was 75.1%, with a P value of 0.002. Based on the lower average score, this is suggestive of the heart failure case being potentially more challenging.

In addition, an analysis of the order of modality was performed. In the heart failure case, there was no significant difference (P = 0.135) between prequiz and postquiz scores for SBL (average score, 57.8% vs. 66.9%), and there was no significant difference (P = 0.761) between prequiz and postquiz scores for PBL (average score, 59.4% vs. 61.2%). In the dysrhythmia case, there was a significant difference (P < 0.001) between prequiz and postquiz scores for SBL (average score, 41.5% vs. 70%), and there was a significant difference (P = 0.011) between prequiz and postquiz scores for PBL (average score, 42.5% vs. 57%). Although the difference in SBL scores with the heart failure case was not significant, there was a 10% improvement or 1 letter grade improvement where we see a 2% improvement with PBL. This also might be suggestive of the heart failure case being more challenging as we previously stated.

The student survey indicates that 76% (n = 22) of students prefer SBL to PBL or didactic lectures, whereas 17% (n = 5) of students prefer didactic lectures. Eighty-six percent (n = 25) of students responded that SBL will increase their ability to care for patients, and 7% (n = 2) replied that PBL would increase their abilities. Table 2 includes the open-ended responses provided by the students related to this question. Although 2 students did not complete the survey, all students who responded thought that SBL increased their confidence.

### DISCUSSION

This study shows the impact of hands-on learning (SBL) compared with another form of active learning (PBL). Within pharmacy education, this is the first report of a crossover comparison involving SBL. The crossover design of this study allowed collection of data from both content areas to correct for any potential confounding content variation or order effects, especially with preintervention results indicating equivalent baseline knowledge. There was no analysis of performance in these topic areas with the simulator before the study. The students had received both PBL and SBL throughout our curriculum before this course and were very familiar with both learning strategies. The assessment of the order of modality confirms that the previous experience of the simulator overrides the order of learning modality. The disease states selected were chosen to intentionally not overlap in material. In addition, the students had at least 6 simulation cases during this course just before this study period; therefore, the order of learning strategy experience should not have impacted their performance.

The higher scores achieved after the SBL sessions in the areas of clinical assessment and development of pharmacotherapy plans, including monitoring, suggest a clinically significant improvement in critical thinking in these clinical areas. Because critical thinking in general is essential for good health care practice, these findings are encouraging. The finding of improved examination performance reinforces that simulation has the potential to improve knowledge of pharmacotherapy.

Based on survey results, the students’ level of satisfaction with the learning environment was high. In addition, students felt that SBL would prepare them to practice clinical pharmacy to a potentially greater extent than PBL would. This is primarily based on the students’ comments regarding the hands-on experience with the simulators, which, according to them, allowed them to make mistakes in a safe environment. Repetition of disease state exposure is an additional factor that SBL provides in a realistic setting. Finally,
the survey showed that student confidence was improved, which could translate in their interactions with other health care disciplines or to patient interactions as suggested by a student comment stating that SBL “removed fear and hesitation.” This is clearly an area that would warrant further investigation to support this claim.

Within medical education, SBL has been found to be superior to PBL for teaching assessment and medical management skills. As seen in other health care disciplines, simulation offers the unique advantage of controlled and standardized experiential training equivalent to traditional experiential learning for a portion of hours required.

**LIMITATIONS**

Several limitations of this study exist and warrant discussion. This was an elective course, so there is potential bias toward student perception of simulation. However, in our previous work, which is primarily in core courses within the pharmacy curriculum, we have shown similar results. Another limitation includes the sustainability of the results. A recent study on simulation education for training practicing intensive care nurses showed a sustained impact of reducing medication errors 3 months after the SBL. Future studies will need to focus on longer durations of sustained effect. Another limitation of the study was found to be that the dysrhythmia and heart failure cases may not have been equivalent based on performance scores. This variation in performance could potentially be explained by the complexity of the variety of medications available for the management of dysrhythmias.

**CONCLUSIONS**

Learning was enhanced with the use of SBL compared with PBL. Students felt that SBL would better prepare them for patient care experiences. The key components of problem solving and critical thinking that were more evident in SBL were the development of a problem list, pharmacotherapeutic plan, and monitoring plan. Simulation-based learning demonstrated an impact on learning during this course, but there is a need for additional research to determine the sustainability of this improvement. Sustainability will be difficult to assess because pharmacy students gain knowledge and confidence in experiential settings and eventually in their practice, making SBL, the independent predictor of success, difficult to measure. An additional need is the evaluation of faculty or facilitator resource utilization in PBL and SBL to determine feasibility.

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**REFERENCES**