The purpose of this study was to compare traditional methods of instruction to the use of audiovisual patient safety vignettes in terms of their impact on student registered nurse anesthetists’ recall and subsequent clinical performance. These vignettes used simulated, crisis-oriented anesthetic events known to be associated with catastrophic patient outcomes. Using a randomized controlled crossover trial, 24 student registered nurse anesthetists encountered either a malfunctioning suction device vignette or a stuck expiratory unidirectional valve vignette. Recall and clinical performances were measured after exposure to a lecture and written case studies or to lecture and patient safety vignettes. Of the 24 students, 23 were able to recognize the malfunctioning components and take corrective action. In this research study, memory and clinical performance were significantly affected when the anesthesia provider incorporated the correct anesthesia apparatus checkout process and crisis management skills into practice. This research demonstrated that under the conditions of this study, teaching methods had an impact on some areas of clinical performance. In this study, crisis-oriented, anesthesia patient safety vignettes had the potential to affect recall and clinical performance in a simulated environment.

Keywords: Anesthesia apparatus checkout procedure, anesthesia clinical performance outcomes, patient safety, patient simulation, teaching methods.
onstration scores, when compared with a matched group exposed to written case studies and standard lecture.

2. The SRNAs exposed to PSV plus standard lecture will exhibit superior recall of apparatus-related material, evidenced by higher group mean posttest scores, when compared with a matched group exposed to written case studies plus standard lecture.

Methods
Approval was obtained from the institutional review boards at both Virginia Commonwealth University in Richmond, Virginia, and Samford University in Birmingham, Alabama. Following approval, 24 students with no prior exposure to anesthesia equipment or delivery systems were randomly divided into 2 study arms using statistical software (Statistical Package for Social Sciences [SPSS] 12.0 for Windows, SPSS, Chicago, Illinois).

To maximize internal validity and increase statistical power, the investigators measured between group performances using a randomized controlled trial that included a dual crossover design. A pretest/posttest knowledge assessment comparison was done to evaluate recall of educational content. The hypotheses stated earlier isolated the PSV as the independent treatment variable.

Before the study, 2 PSVs were developed, filmed, and edited by a panel of 4 investigators at Virginia Commonwealth University, Richmond, Virginia. Additionally, the PSVs were assessed for, and achieved, high face validity, as measured at a variety of subsequent departmental and regional meetings attended by CRNAs, anesthesiologists, and hospital administrators. The first PSV depicted a patient death that resulted from provider negligence related to a broken suction canister. The second PSV showed a catastrophic patient event related to an anesthesia machine’s stuck expiratory valve that went undetected by the provider. Both scenarios depicted actual case events known to the authors from closed claims research.

Both groups received a pretest related to a baseline knowledge of the anesthesia machine preoperative checkout process. This was followed by a lecture and demonstration on the American Association of Nurse Anesthetists’ Standards of Care and the Food and Drug Administration (FDA) Anesthesia Apparatus Preoperative Checkout Procedure. The lecture and demonstration provided foundational knowledge regarding the appropriate method for preoperative checkout of the machine.

One week later, after randomization into 2 groups, the first group was shown the vignette with the scenario of the malfunctioning suction device. The second group viewed the vignette with the stuck unidirectional expiratory valve scenario. Separately, each group was also given the written case study from the vignette scenario not viewed (Figure 1). Steps 12 and 14 of the FDA checkout procedure were selected as testing measures because of available resources and the ability for the researchers to “sabotage” the involved anesthesia machine components without obvious detection. Step 12 involved inspection of the unidirectional valves, and step 14 was verification.
of working suction apparatus. For simplicity, step 12 was referred to as “valve” check, and step 14 was referred to as the “suction” check.

The groups received the interventions in separate rooms, at the same time, under identical conditions. The case studies consisted of exact transcriptions of the content contained in each PSV in much the same form as a traditional published case report (Figure 2). After viewing the PSVs, each group was allowed a 20-minute proctored discussion regarding the scenarios. Each group was proctored by the same instructor using scripted, open-ended, guided discussion questions.

A 2-week washout period was given, followed by an SRNA individual hands-on return demonstration of the preoperative anesthesia machine checkout procedure. This procedure included “sabotaged” components, that is, a stuck unidirectional valve and a malfunctioning suction apparatus. The hands-on demonstration took place in the human patient simulation laboratory at Samford University, Birmingham, Alabama. Each SRNA was allowed to sign up for a preferred time for demonstrating the FDA checkout process. Two consecutive dates were available for SRNA demonstration. To discourage discussion regarding the demonstration process and scoring procedure, a confidentiality form, along with the Samford University Student Code of Ethics, was signed by each participant. Additionally, there was a 10-minute empty time slot between each demonstration to allow participants to leave and enter the simulation laboratory with minimal contact with other participants.

Data were collected on each participant, and 1-way analysis of variance procedures were done using SPSS 12.0 to evaluate differences between groups 1 and 2. For assessment of clinical performance, data were collected on identification (or not) of the malfunctioning devices, corrective measures taken (if any), total time the SRNA required to accomplish the checkout procedure, and the time used for each step of the FDA checkout procedure specifically involving the malfunctioning component.

Recall was assessed via posttesting. The posttest included the same subject matter as the pretest plus an additional set of questions specific to the sabotaged components.

### Results

Clinical performance was measured and scored for each student using 5 specific data collection points during a simulated event. Each student demonstrated the full anesthesia machine checkout process (Table 1).

Twelve participants were randomly placed into group 1, and 12 others into group 2. Step 12 of the FDA checkout procedure involves a manual check and inspection of the unidirectional valves. For the first data point measurement, each subject was timed from the start of step 12 until the subject either identified the malfunctioning unidirectional expiratory valve (CPVal) or completed the entire step. This method was repeated for step 14, the nonfunctioning suction apparatus (CPSuc), which served as the second data point. Step 14 of the FDA checkout procedure involves checking the final status of the machine, which includes ensuring that patient suction is available and functioning. For the purposes of data reporting, the terms total time and identification were chosen to distinguish the 2 data points. (See Table 2 for a complete list of abbreviations used in this study.)

The third data point measurement used was the total time that the subject took to complete the entire anesthesia checkout process (CPTotaltime). The fourth and fifth data point measurements, that is, identification of the malfunctioning components, were considered the assessment outcome of the subject’s application of learned knowledge to clinical practice.

Pretest/posttest knowledge changes revealed significant results in students’ score improvements for group 2 \(P = .001\). Insignificant results for group 1 were obtained \(P = .83\), indicating little to no improvement between pretest and posttest scoring.

Hypothesis 1 predicted that clinical performance would be improved in SRNAs exposed to simulated...
crisis-oriented PSVs. Clinical performance measures revealed mixed results for step 12 (anesthesia machine unidirectional expiratory valve check) and step 14 (suction device functionality). Group 1 (PSV on malfunctioning suction device and written case study group) was associated with faster clinical performance times for total machine checkout (P = .009), steps for identification of the malfunctioning suction device (P = .04), and clinical performance on correction of malfunctioning of suction, P < .001). Marginally significant results were obtained for SRNA identification of the stuck expiratory valve (P = .06) in both the PSV and the written study for that component. Significantly faster SRNA checkout times were noted for the malfunctioning suction vignette group (P < .001), whereas clinical performance analysis for the stuck expiratory valve vignette group yielded insignificant results (P = .11) and slower SRNA performances (Figure 3).

One week following the hands-on demonstration of the anesthesia apparatus checkout procedure, a criterion-referenced posttest consisting of 11 questions was given to all subjects as one group, 20 minutes in duration. Posttest questions 1 to 5 were identical to the pretest questions. Posttest questions 6 to 12 were designed to elicit subject recall of specifics contained in the 2 scenarios. All subjects’ scores improved from pretesting to posttesting with the exception of 1 subject.

Table 1. Explanation of Data Points

<table>
<thead>
<tr>
<th>Data point</th>
<th>Abbreviation</th>
<th>Measurement detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical performance, total seconds, steps 12 and 14</td>
<td>CPTotalsec</td>
<td>Total time taken by SRNA to complete both step 12 and step 14 of the FDA Anesthesia Apparatus Checkout Procedurea</td>
</tr>
<tr>
<td>Clinical performance malfunctioning unidirectional expiratory valve</td>
<td>CPVal</td>
<td>Time taken by SRNA to complete step 12 or until valve was identified as malfunctioning</td>
</tr>
<tr>
<td>Clinical performance nonfunctioning suction apparatus</td>
<td>CPSuc</td>
<td>Time taken by SRNA to complete step 14 or until suction device was identified as nonfunctioning</td>
</tr>
<tr>
<td>Identification of malfunctioning unidirectional expiratory valve</td>
<td>IDVal</td>
<td>Proper SRNA identification of the stuck unidirectional valve, Yes/No</td>
</tr>
<tr>
<td>Identification of nonfunctioning suction apparatus</td>
<td>IDSuc</td>
<td>Proper SRNA identification of the nonfunctioning suction device, Yes/No</td>
</tr>
<tr>
<td>Identification of nonfunctioning suction apparatus</td>
<td>CPTotalsec</td>
<td>Sum of seconds taken to complete step 12 (expiratory valve step) and step 14 (malfunctioning suction apparatus)</td>
</tr>
<tr>
<td>CPTotaltime</td>
<td>CPTotaltime</td>
<td>Total time taken to complete the entire FDA anesthesia apparatus checkout procedure</td>
</tr>
<tr>
<td>Recall 1-5</td>
<td>Recall 1-5</td>
<td>Questions numbered 1-5 (same as presented in the pretest) on the posttest</td>
</tr>
<tr>
<td>Recall 6-11</td>
<td>Recall 6-11</td>
<td>Questions numbered 6-11, focusing specifically on direct information contained in the valve vignette and written case study</td>
</tr>
<tr>
<td>Valve questions: PTVal7, PTVal9, and PTVal10</td>
<td>PTVal (#)</td>
<td>Posttest questions related to the valve scenario (Example PTVal7 = posttest valve question 7)</td>
</tr>
<tr>
<td>Valve questions: PTVal7, PTVal9, and PTVal10</td>
<td>PTSuc (#)</td>
<td>Posttest questions related to the suction scenario (Example PTSuc6 = posttest suction question 6)</td>
</tr>
</tbody>
</table>

Table 2. Glossary of Abbreviations

Abbreviation | Representation |
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>CPVal</td>
<td>Clinical performance for valve vignette group</td>
</tr>
<tr>
<td>CPSuc</td>
<td>Clinical performance for suction vignette group</td>
</tr>
<tr>
<td>IDVal</td>
<td>Correct identification of malfunctioning valve during clinical performance in the hands-on demonstration of the Food and Drug Administration (FDA) anesthesia apparatus checkout procedure</td>
</tr>
<tr>
<td>IDSuc</td>
<td>Correct identification of malfunctioning suction apparatus during clinical performance in the hands-on demonstration of the FDA checkout procedure</td>
</tr>
<tr>
<td>CPTotalsec</td>
<td>Sum of seconds taken to complete step 12 (expiratory valve step) and step 14 (malfunctioning suction apparatus)</td>
</tr>
<tr>
<td>CPTotaltime</td>
<td>Total time taken to complete the entire FDA anesthesia apparatus checkout procedure</td>
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<tr>
<td>Recall 1-5</td>
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<td>PTSuc (#)</td>
<td>Posttest questions related to the suction scenario (Example PTSuc6 = posttest suction question 6)</td>
</tr>
</tbody>
</table>

*Step 12 is inspection of the unidirectional valves; step 14, verification of working suction apparatus.
Abbreviations: FDA, Food and Drug Administration; SRNA, student registered nurse anesthetist.
No significant difference existed between group pretest scores ($P = .83$) and posttest scores ($P = .11$), an expected finding since the subjects were not divided into vignette and written case study sections for this analysis.

Hypothesis 2 predicted that recall would be improved as evidenced by higher group mean posttest scores. A 2-tailed, paired-samples t test was performed to test the difference between group means between the 2 variables. The results supported the hypothesis that recall was greater in the vignette groups ($P < .001, \alpha = .05$) as opposed to the written case study groups.

**Discussion**

Allan Paivio’s Dual Coding Theory was used as the theoretical framework for this investigation. This theory suggests that the verbal and visual cognitive processing mechanisms are separate functions, yet are interwoven to synthesize information. On retrieval, the images and emotion-evoking experiences are remodeled. Paivio’s work revealed that visual imagery had a greater impact on long-term memory and was more readily retrievable than information coded as verbal. Significant results in clinical performance measures may demonstrate higher cognitive processes, rather than simple memorization, and may indicate that information synthesis has occurred. Figure 4 illustrates the essential elements of Dual Coding Theory.

In this study, failure to identify a device malfunction while performing the anesthesia machine checkout process suggested an absence of application of knowledge to clinical practice. The total time taken by the SRNA to successfully complete each step was considered to represent a viable metric of application of learned knowledge to the machine checkout process. Longer times may represent subject difficulty in applying the learned concepts. Shorter times may suggest superior and more efficient application of knowledge to clinical performance. Proper identification of the nonfunctioning component demonstrated that the subject was able to access and apply learned knowledge to the FDA’s machine checkout procedure. It is implicit that should the SRNAs accurately and reliably incorporate knowledge learned from their education, then a potential for improved patient safety exists. Patient safety vignettes may represent an educational tool possessing significant cognitive imprint and patient safety implications.

As with any simulation, the potential exists for inadequate representation of reality. Although both case studies clearly described the emotive components found within the vignettes and both yielded catastrophic patient outcome, it is possible that the emotive components...
ponents conveyed in the written materials may have had variable impact on the participant. This may have influenced SRNAs’ memory and vicarious learning processes between the scenarios. Previous individual SRNA emotional experiences may have affected the degree to which learning occurred. If the emotive components of the vignettes or case studies were similar in any way to a previous experience, the SRNAs’ knowledge retention may have been greater. Rather than focusing solely on training, the PSVs were designed to provide a meaningful educational experience for the SRNA. The PSVs used have a high degree of authenticity, as we have previously demonstrated. Another limitation to the study was found in the instrumentation. There is no standardized data collection tool for determining knowledge application related to the anesthesia machine checkout process. In this study, the tool was carefully designed, was shown to have high face validity, and was criterion referenced.

Results from this study indicate that including crisis-oriented high-fidelity audiovisual vignettes may not only enhance retention of material but also may improve clinical performance as cognition/memory is enhanced as predicted by Dual Coding Theory. It was demonstrated that under the conditions of this study, crisis-oriented, anesthesia PSVs have the potential to affect recall and clinical performance in a simulated environment. It has been suggested that education along a continuum, such as simulation in conjunction with traditional teaching methods and hands-on beside practice, is the most effective method of healthcare education.

Because of the small sample size and because the tools for measuring clinical performance were newly designed for this particular study, findings from this study cannot be generalized to any other group or population. Findings from this research merit further investigation into the potential use of vignettes as an educational method to affect clinical practice and safety.

REFERENCES

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