The purpose of this study was to determine which method of teaching, CD-ROM, simulation, or a combination of both, was more effective in increasing the performance of ultrasound-guided regional anesthesia. No studies have investigated these methods.

The framework for this study was critical thinking. The study was a prospective, mixed (between and within) subjects, experimental design. The sample consisted of 29 student registered nurse anesthetists randomly assigned to 1 of 3 groups: CD-ROM (n = 11), simulation (n = 11), and combination (n = 7). All groups were evaluated by the use of cadavers before and 2 months after the intervention using a valid and reliable instrument of performance.

A repeated-measures analysis of variance indicated that the combination was significantly better than the CD-ROM and simulation (P < .05). The means and standard deviations for pretest and posttest results, respectively, were: CD-ROM, 33 ± 7%, 41 ± 9%; simulation, 35 ± 10%, 49 ± 13%; and combination, 36 ± 8%, 64 ± 17%. The baseline for each group was 0. Use of a combination of CD-ROM and simulation should be considered in teaching ultrasound-guided regional anesthesia techniques.

Keywords: CD-ROM, human simulation, ultrasound-guided regional anesthesia.

Ultrasound-guided regional anesthesia (UGRA) is a new and exciting technology that may become the standard of care, particularly in the military. Military Certified Registered Nurse Anesthetists (CRNAs) and faculty teaching military student registered nurse anesthetists subscribe to the proposition that graduates should have the skills necessary for performance of UGRA and that it should be part of the practice for CRNAs in addition to traditional methods of peripheral nerve blockade.

Military student registered nurse anesthetists have extensive education in the practice of both traditional regional anesthesia and UGRA as well as ample opportunities to practice these skills in their clinical practicums. As a result, educational guidelines and prospective outcomes studies are required to develop curricular requirements that will maximize clinical benefits. However, it is not known what type of teaching strategies provide the best method of teaching the use of ultrasound in successfully implementing regional anesthesia.

Simulation may be an effective method of teaching UGRA. Simulation is defined as a realistic representation (model) of the real-world dynamics or processes that reflect or parallel patient scenarios.1 Jeffries2 emphasizes that simulation is a teaching strategy that can be used to facilitate making connections between and among concepts through a process that actively engages students in learning. According to Kaakinen and Arwood,3 such a strategy facilitates learning skills and knowledge.

The theoretical framework used for this project was critical thinking. Critical thinking is a process of seeking information, collecting data, discriminating between relevant and nonrelevant data, analyzing situations, applying standards of care, using logical reasoning, and performing the appropriate skills. For the purposes of this study, critical thinking was defined as the process of correctly identifying the proper surface landmarks, verbalizing the surgical indications (dermatomes blocked, type of surgery for which this block is recommended), performing correct manipulation with the ultrasound probe, correctly identifying the proper ultrasound landmarks, using ultrasound, and correctly inserting needles for 4 nerve blocks (interscalene, supraclavicular, infraclavicular, and axillary).
Review of the Literature

Very little prospective, randomized, experimental research exists on the use of simulation as a teaching method, and, to the authors’ knowledge, no studies have compared the use of CD-ROM with simulation relative to performance of UGRA. A wealth of literature addresses the value of using simulation as a teaching method but fails to use a rigorous research design. Korndorffer and colleagues found that simulation showed a significant improvement in overall scores from baseline for performing laparoscopic suturing, but they did not compare simulation with any other teaching method. Rauen found that simulation as a method of teaching allows learners to apply theory to practice in an integrated manner. Furthermore, she found that a simulator has the capacity to demonstrate more than a single event or parameter at a time, which allows participants to identify relationships that are essential and common to clinical practice. She found that the evaluation of the simulation sessions were universally positive. Because of the use of simulation, students became confident and were able to demonstrate skills learned. However, Rauen did not compare the simulation approach with any other method or with a control group. Ben-Menachem and colleagues investigated the use of objective structured clinical examination (simulation) to assess trainees’ level of professional competence in regional anesthesia before their taking the national board examination. They found that, “testing formats that more closely reflect clinical practice are potentially valuable adjuncts to traditional examinations.”

In 2008, Johnson and colleagues investigated the effectiveness of using the simulation compared with a CD-ROM group in teaching care of patients exposed to chemical warfare agents for military nurses. They found that there were no significant differences in lower-level cognition between the 2 approaches, but that simulation was more effective relative to higher-level cognition and critical thinking. In another study, Johnson et al found that the use of human patient simulation was superior to the CD-ROM in learning care of patients exposed to chemical warfare. Recently, Johnson and colleagues compared the use of a human patient simulator with a CD-ROM relative to caring for trauma patients. They found that the human patient simulator was superior to the CD-ROM relative to higher-level cognition, critical thinking, and actual performance of care. Steadman et al also found that simulation-based training was superior to problem-based learning for the acquisition of critical assessment and management skills.

In another study, Hoadley compared results of 2 Advanced Cardiovascular Life Support (ACLS) classes on measures of knowledge (content examination) and resuscitation skills (performance examination). The control group used low-fidelity simulation; the experimental group was exposed to enhanced realism via high-fidelity simulation (HFS). The HFS group scored higher on both cognitive and behavioral tests, but the difference was not statistically significant. The experimental group stated that learning using HFS was enjoyable and adamantly recommended that ACLS should be taught only using HFS.

Although a plethora of research exists on simulation, investigators stress there are limited rigorously designed pretest-posttest studies of simulation, and they emphasize the need for investigations of simulation that compare the approach with other educational methods. Rourke et al reviewed the literature relative to simulation and found that HFS is used extensively in nursing education but concluded that research does not justify their use. Hoadley supports the use of simulation but struggles to substantiate his opinions because of a lack of experimental research.

Materials and Methods

The purpose of this study was to determine the effectiveness of 2 different methods of teaching UGRA for military student registered nurse anesthetists: specifically CD-ROM and human simulation. The following research question guided the study: Is there a statistically significant difference between use of a CD-ROM, human simulation, and a combination of both as educational strategies relative to the performance of UGRA? The study was a mixed (within and between) subjects, prospective, repeated-measures, pretest and posttest experimental design. To determine the number of subjects needed, the investigators calculated an effect size using other simulation research. Using the means and standard deviations of that study, the investigators calculated a medium effect size of 0.5. Using a medium effect size of 0.5, an α of .05, and a power of 0.8, the investigators anticipated that 24 participants were needed for the study, 8 in each group. The study was approved by the local institutional review board.

After review of the literature, the investigators developed a CD-ROM and created a script for using a live model for simulated UGRA. The CD-ROM covered essential content using ultrasound for 4 nerve blocks: interscalene, supraclavicular, infraclavicular, and axillary. Content included the identification of the proper surface landmarks, the surgical indications (dermatomes blocked, type of surgery for which this block is recommended), demonstration of the correct manipulation with the ultrasound probe, and methods of correctly identifying the proper ultrasound landmarks. The script for the live simulation consisted of the same content demonstrated on a real person. Both were 20 minutes in length. Both the CD-ROM and the simulation script were reviewed by 2 experts who approved the content. The experts had a 100% agreement that the content was accurate and comprehensive.

The Regional Anesthesia Evaluation Instrument (RAEI) was developed to determine the participants’
ability to use ultrasound. The RAIEI was developed in coordination with 3 other faculty members who teach and perform UGRA as part of their practice. The criteria for the RAIEI were developed from various instructional manuals and books. The instrument consisted of 16 criteria, each anchored by “met” or “not met.” The criteria were reviewed by a panel of 4 experts who utilize and teach UGRA (Table 1). After revision, the experts were in complete (100%) agreement that the content of the test was valid, specifically that each criterion was essential and reflected performance evaluation. Stability for the instrument was established by the administration of the tool to 29 participants, and by retesting in 2 months. During the 2-month interval between the first and second evaluations, no formal instruction was provided to the participants. A Pearson correlation coefficient was calculated using the scores for both tests. A strong positive correlation ($r = .93$, $P = .001$) indicated that the instrument was stable over time.

Potential participants were recruited from the 2011 class of the US Army Graduate Program in Anesthesia Nursing. An invitation to participate in the research study was presented by an ombudsman, who stressed that lack of participation in this study had no negative impact on their status as students in the program. A consent form was signed and witnessed. Participants completed a demographic data sheet that included the following: type of nursing experience, years of experience, gender, ethnicity, age, and military rank. These data were collected to describe the sample and to determine if there were any intervening variables relative to the outcome variables. After the consent form was signed, all participants were evaluated by the same investigator using the RAIEI to determine baseline measurement of their ability to use ultrasound for regional anesthesia. Participants were randomly assigned (by use of a computer random number generator) to 1 of 3 groups: CD-ROM, simulation, or a combined group.

After the pretest (baseline test) was administered, subjects received instruction by CD-ROM, simulation, or combination. The CD-ROM group watched an instructional video that demonstrated the nerve blocks to be evaluated. The human simulation group saw the same content from the CD-ROM but on a live person. The combination group saw both the CD-ROM and the human simulation perform all the blocks evaluated. None of the groups was allowed to ask any questions during any of the demonstrations.

One month later, each participant’s performance was evaluated with the RAIEI on cadavers. One month after the performances were evaluated, the participants, staying in their original groups, received repeated instruction by CD-ROM, simulation, or combination. One month later (3 months total), the participants’ performance was again evaluated by the RAIEI on cadavers.

### Results
The original sample consisted of 33 participants (11 students in each group). However, because of attrition (4 students in the combination group), the sample consisted of 29 student registered nurse anesthetists, with only 7 members of the combination group. Their ages ranged from 26 to 47 years. The rank ranged from Second Lieutenant to Lieutenant Colonel.

A multivariate analysis of variance (ANOVA) indicated that there were no significant difference between groups in years of experience, age, and RAIEI scores at baseline and 1 month ($P > .05$), indicating that the groups were equivalent on the parameters. A repeated-measures ANOVA and a least significant difference post hoc analysis indicated that the combination was significantly better at increasing performance of UGRA than the CD-ROM or simulation ($P < .05$) and that no difference existed between the CD-ROM and simulation ($P > .05$). The means and standard deviations for baseline, 1-month, and 2-month scores on the RAIEI are summarized in Table 2.

### Discussion
Based on the results of this study, the use of a combina-

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**Table 1. Scoring for Ultrasound-Guided Regional Anesthesia**

- **Axillary block**
  1. Identification of proper surface landmarks
  2. Verbalization of correct dermatomes/nerves blocked
  3. Correct manipulation of ultrasound probe
  4. Correct identification of proper ultrasound landmarks

- **SuprACLavicular block**
  1. Identification of proper surface landmarks
  2. Verbalization of correct dermatomes/nerves blocked
  3. Correct manipulation of ultrasound probe
  4. Correct identification of proper ultrasound landmarks

- **InfraClavicular block**
  1. Identification of proper surface landmarks
  2. Verbalization of correct dermatomes/nerves blocked
  3. Correct manipulation of ultrasound probe
  4. Correct identification of proper ultrasound landmarks

Each item was scored as follows: no = 0 points; yes = 1 point.

To minimize experimenter effect, the same investigator evaluated all students.
tion of a CD-ROM and simulation is more effective than either of the other 2 methods (CD-ROM or simulation) at increasing performance of UGRA among student registered nurse anesthetists. The study used a prospective, repeated-measures (baseline, 1 month, and 2 month), 3-group randomized design. Baseline and 1-month scores of the CD-ROM group, simulation group, and combination group did not significantly differ, indicating that the groups had approximately the same initial scores on the instruments. The posttest 2-month scores indicated a significant difference between the combination group and the CD-ROM and simulation groups, but there was no significant difference between the CD-ROM and simulation.

The results of this study, although intuitive, suggest that combining the use of 2 different strategies to teach UGRA is more effective than using the strategies separately. Students learn more by having more instruction and using a combination of modes. Additional recommendations for future research include using the same framework for different content and investigating other teaching methods besides CD-ROM and simulation.

REFERENCES

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