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Keywords
peer-assisting learning; peer teaching; self-instructed video; basic airway management; undergraduate nurse; simulation

Abstract
Background: Innovative peer-to-peer teaching has the potential to emphasize student self-learning and reduce the workload of the instructor.
Method: This single-blinded randomized crossover trial was conducted to evaluate whether peer-to-peer teaching is not inferior to standard teaching in basic airway management for undergraduate nursing students.
Results: Forty-eight students with the peer-to-peer learning had significantly higher skill rating scores with a large effect size (Cohen’s d of 1.07 (p-value .002) for oropharyngeal airway insertion, 1.14 (p-value <.001) for nasopharyngeal airway insertion, and 0.81 (p-value .003) for bag-mask ventilation). There was no difference between preknowledge and postknowledge scores (p-value of .13 and .22, respectively). Both groups reported higher confidence.
Conclusions: Nursing students trained in basic airway management by the peer-to-peer method did not show inferiority compared with the standard group.

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Key Points

- Undergraduate nursing students who learned basic airway management with the peer-to-peer instructional method had significantly higher skill checklist scores than those who learned with standard instructor-led teaching; effect sizes were large.
- Students who learned by the peer-to-peer teaching method also had an opportunity to develop their teaching skills which is a ‘value-added’ skill for their future practice.
- This blended learning approach with the added innovation of peer-to-peer instruction and a highly structured self-instruction video and feedback system has the significant benefit of reduced cost and decreased instructor workload.

Basic airway management is an essential skill for health care providers. Nowadays, these skills are commonly taught by expert instructors who lead face-to-face teaching (Sun, Pan, Li, & Gan, 2017). There are several disadvantages to this approach, including the cost of obtaining qualified instructors. Expert instructors may also prolong sessions by providing didactic information, thus limiting the actual practice time. Another limitation of teaching by an expert is logistical in nature because of the need to schedule a timetable around the often-fixed schedules of these subject-matter experts. Structured curricula, including the use of self-instruction videos, have been shown to be as effective as standard face-to-face instruction in certain circumstances such as for teaching basic airway management, cervical collar application, emergency extremity splinting skills, manual cardiac defibrillation, and automated external defibrillator (Saiboon, et al., 2014, 2016). In these situations, trainees have demonstrated comparable confidence and psychomotor learning outcomes when compared with a traditional teaching approach. Peer-to-peer instruction is also an approach that has been demonstrated to be effective. Concepts of self-reflection, self-assessment, peer assessment, and peer feedback are currently thought to be the principles that underlie this approach across multiple applications for medical curricula (Burgess, et al., 2018). Teaching students the process of reflective practice through peer-to-peer interaction is thought to stimulate critical thinking, assist with problem-solving, and help emphasize the lifelong skill of self-directed learning. The peer-to-peer approach also helps participants gain new understanding, offers a fresh perspective, and reveals alternative educational pathways that may help accelerate future skill acquisition (Ménard & Ratnapalan, 2013).

There have been no reports in the literature of a structured curriculum model for peer-to-peer instruction of basic airway management for nursing students although other skills ranging from obtaining a blood pressure to performing a sterile technique using a ‘bundled’ curriculum have been reported (Blazeck & Zewe, 2013). It is hypothesized that an innovative structured curriculum that includes a combination of self-instruction videos, peer-to-peer instruction, and guided peer-to-peer feedback using structured debriefing, such as the gather, analyze, and summarize (GAS) model, will be as effective as standard instructor-led teaching of novice nursing student acquisition of basic airway management knowledge, skill, and confidence. The peer-to-peer educational method has the potential to be a cost-saving alternative for teaching basic airway management. It can help address the problem of maintaining high-quality education in the setting of rapidly increasing number of health care student trainees yet a fixed number of instructors.

Angeli (2020) remarked that the noninferiority trial is suitable when a new intervention is thought to be less costly or more practical than the standard one but does not necessarily have to be more effective on the primary outcome. It is possible to define that the experimental condition is not worse than the control by demonstration of an acceptable difference. This difference is termed the noninferiority margin. If the peer-to-peer education method can be demonstrated to be not inferior to the standard instruction, this method could be applied for a wide variety of learning objectives across a range of skills or techniques. Examples include noninferiority studies by Tolsgaard (2015) and Musits (2019).

The purpose of this study was to evaluate whether peer-to-peer instruction supported by a structured curriculum and video exemplars is not inferior to standard expert
inSTRUCTION OF BASIC AIRWAY MANAGEMENT IN THE AREAS OF KNOWLEDGE, SKILL, AND CONFIDENCE LEVELS.

THEORETICAL FRAMEWORK

Self-directed learning is an important element in adult learning theory. Lindeman (1926) noted that “Adults have a deep need to be self-directing.” This principle of self-direction is a key assumption when working with adult learners.

Knowles (1975) identified that adults learn more effectively with self-directed learning approaches that offer the opportunity to take the initiative in their own learning and also to learn according to processes inherent to their own psychological development.

Tough (1967) proposed three specific keys for promoting self-teaching, which are self-selection, promotion of the independent study, and the use of programmed instruction and teaching machines. The innovative teaching method in this study supports Tough’s idea of the use of programmed instruction. Peer-to-peer teaching promoted the self-directed learning by using the self-instruction videos, peer-to-peer instruction combined, and guided peer debriefing.

MATERIAL AND METHODS

A single-blinded, randomized crossover trial was conducted with 48 undergraduate nursing students who were aged between 18 and 65 years and identified as novice level with respect to basic airway management. After obtaining exempt institutional review board approval for the study through the University of Pittsburgh, investigators began recruitment. Subjects were recruited through a broadcast e-mail sent to nursing professors, as well as through recruitment scripts that were placed in public areas at the University of Pittsburgh School of Nursing. After expressing interest, participants contacted the principal investigator, were read a research script, and instructed to register for an account through the Peter M. Winter Institute for Simulation, Education and Research (WISER) simulation information management system web portal. After registration, participants entered the password-protected research portal and completed an online precourse survey (to attain demographic and attitude data) and a 10-item knowledge quiz. After the precourse survey and quiz were completed, all participants were directed to review an online self-study module on basic airway management. Completion of this module was verified through the simulation information management system course-reporting dashboard function. They were then scheduled for learning sessions at WISER. Participants were randomized into two groups (peer-to-peer and expert instructor) through a computer-generated program (Figure 1). The learning sessions were two hours in duration after which the participants were instructed to access the online research course portal and complete the postcourse attitude and knowledge evaluations. After completion of the instruments, expert instructors offered a supplemental instructional session to the students who had received peer-to-peer instruction for either bag-valve-mask ventilation or

Figure 1 Flowchart of the study. Note. MCQ, multiple-choice question.
airway management. This was performed to ensure that all students had an opportunity to receive ‘standard’ instruction in these skills.

**Survey and Knowledge Test Development**

The prelearning and postlearning surveys were created in a mirror pattern to measure four learning components. The four components are the following: knowledge confidence, stress during class, self-perception of knowledge, and preknowledge to postknowledge acquisition. The prelearning and postlearning surveys measured the first three components using a Likert scale, in which each item was rated from 1 (strongly disagree) to 5 (strongly agree). In the postlearning survey, there was an additional question included which evaluated participants’ preferences between peer-to-peer and standard expert training of basic airway management skills.

Knowledge acquisition was measured with an online 10-item multiple-choice question assessment. The content was validated in an iterative fashion by referencing each item to published literature and through expert consensus by three airway experts who are RNs and certified registered nurse anesthetists. The three airway experts were female faculty members of a large U.S. University with an average of 14.7 years of clinical experience (range 8-25 years). These faculty experts were not a part of the research team. After initial validation, the assessment had a test-retest reliability coefficient of 0.82 from pilot tests administered to a separate group of 28 nursing students. No changes were made to assessment items based on the reliability evaluation.

**Development of the Skill Checklists**

The checklists for each skill were developed by using the standard procedural manual from prehospital trauma life support as a guideline (McSwain & Pons, 2016). An online Modified Delphi process was used to validate the content and the steps of the checklist. There were 13 airway experts, from three nations with more than 240 years of combined airway experience (mean 20.3, SD 11.7) involved in the modified Delphi process. Each expert reported managing at least 700 airways within the past two years. Overall agreement with the items on the oral airway, nasal airway, and bag-mask ventilation skills was high ranging from 0.82 to 0.98 average agreement (Table 1). Two blinded, independent attending emergency room physicians working in a large, urban emergency room setting served as the raters for the skill videos. These attending emergency physicians reported airway management experience of greater than 8 years. The inter-rater reliability (by Cohen kappa coefficients) among the raters was 0.77 for oropharyngeal airway, 0.84 for nasopharyngeal airway, and 0.81 for bag-mask ventilation.

**Simulation Setting and Devices**

All simulation sessions were conducted at the WISER Institute of the University of Pittsburgh. WISER is an 18,000 square foot, state-of-the-art, interprofessional simulation center, which hosts more than 15,000 simulation encounters annually. The manikins used in the study were Laerdal SimMan® (Laerdal Inc., Stavanger, Norway) patient simulators because the airway structure realism is similar enough to a patient for effective training of basic airway techniques. The following airway scenarios were introduced during the various learning sessions:

1. A 32-year-old male is brought to your department after a motorcycle accident. He is unconscious and breathing loudly. You want to assist his breathing by inserting an oropharyngeal airway. Please perform this procedure step by step.
2. A 45-year-old woman has taken an overdose of sleeping pills and is brought to the emergency room by her husband. She is semiconscious and snoring.

### Table 1 Overall Rater Agreement on the Skill Checklist for the Oropharyngeal Airway (6 Items), Nasopharyngeal Airway (6 Items), and Bag-Mask Ventilation (7 Items)

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Oropharyngeal Airway</th>
<th>Nasopharyngeal Airway</th>
<th>Bag-Mask Ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>Item 2</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>Item 3</td>
<td>0.75</td>
<td>0.58</td>
<td>1</td>
</tr>
<tr>
<td>Item 4</td>
<td>0.58</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Item 5</td>
<td>0.83</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Item 6</td>
<td>0.92</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Item 7</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td>0.82</td>
<td>0.90</td>
<td>0.98</td>
</tr>
</tbody>
</table>
You want to assist her breathing by inserting a nasopharyngeal airway. Please perform this procedure step by step.

3. A 63-year-old man has difficulty breathing for 2 days. His diagnosis is severe pneumonia. Your attending staff orders you to give him one-person bag-mask ventilation. Please perform step-by-step bag-mask ventilation and administer at least 3 breaths.

Study Flow

Subjects participated in two learning sessions: the oropharyngeal/nasopharyngeal airway insertion and the bag-mask ventilation session (Figure 1). Each session was one-hour long. Participants were randomly assigned to either the peer-to-peer learning or the expert learning group. There were two students in each group. Half of the participants were assigned to learn the airway (oral and nasal) insertion by peer-to-peer instruction first and then crossed over to the expert instructor teaching group for bag-mask ventilation skills. The first groups were labeled as “group 1.” The other half of participants learned airway insertion through expert instruction and then crossed over to the peer-to-peer teaching for bag-mask ventilation skills. These groups were labeled as “group 2.” After each session, each participant’s performance was recorded on video without showing the participant’s face or other identifying information. As noted, these videos were later viewed and rated by the two blinded observers.

The Standard Instructor-Led Teaching Method

The instructors in the standard expert teaching group were four experienced critical care nurses in the third year of a graduate-level nurse anesthesia training program. Each instructor had verified expertise in basic airway management (at minimum 600 successful airway management experiences within 2 years.) All instructors were oriented to teach the basic airway management skills in this study for standardization of teaching techniques before the learning sessions. The instructors debriefed each skill attempt using the GAS debriefing model, which is the recommended model at WISER. The participants in the instructor-led teaching session had time to practice skills as much as they needed under instructor guidance in the allotted one-hour time period.

The Peer-to-Peer Learning Method

The peer-to-peer learning method allowed one participant to learn with another participant with the guidance of self-instruction videos. The self-instruction videos contained steps of the specific basic airway management skill, as well as a review of the GAS debriefing model to guide peer review of airway skills. The knowledge content of the self-instruction videos was reviewed for validity by the three nurse anesthesia faculty airway experts and two experienced simulation educators with more than 30 years of combined experience in simulation education and airway management. After the participants watched the videos, they received a checklist for each basic airway management skill to use as a guide for practice and reflection. The participants in the peer-to-peer learning group also had opportunity to practice the skills and debrief in the allotted one hour.

Statistical Analysis

For sample size calculation, the standard deviation of 12.41% for basic airway management objective structured clinical examination scores after self-instruction video was used (Saiboon et al., 2014). On a priori basis, noninferiority was determined if the lower bound of the two-sided 95% confidence interval of the mean difference did not exceed...
a 10% margin. With 80% power (1-β), 0.05 significance level (α), and 10% noninferiority limit (d), the calculated sample size was 20 students per group.

Categorical data were analyzed using Fisher’s exact test. The Wilcoxon signed-rank test and the Mann–Whitney U-tests were used for calculation of comparisons between pre-confidence and postconfidence and Likert scale data. Cohen’s kappa coefficient was used to demonstrate the inter-rater reliability for skill assessment. After noninferiority was established, skill improvement effect sizes between peer-to-peer and expert instruction were calculated using Cohen’s d, in which the values of ≥0.80 are considered a large effect, 0.50 to 0.80 are a medium effect, and 0.20 to 0.50 are a small effect. Statistical analyses were conducted using SPSS, V.18.

**Results**

A total of 48 nursing students participated in the study during May 2017 to July 2018. Twenty-four participants were assigned to group 1, and the other half were in group 2. A majority of participants (69%) were women, and the median age was 25 years. Some subjects reported previous experience in basic airway management through didactic instruction in airway management or through practice with hands-on skill with manikins. None of them reported having performed airway management with actual patients. There were no significant differences between the two groups relative to previous airway knowledge or skill (Table 2).

When comparing the skill rating scores across the two groups, the upper limit of the 95% confidence interval for each skill was less than the established 10% margin (Table 3). These results demonstrate that for basic skill teaching, the peer-to-peer method is noninferior to standard teaching. With further analysis, it was clear that the peer-to-peer skill scores were higher than those of the students in the standard teaching group with a large calculated effect size for each skill. We calculated a Cohen’s d of 1.07 (p-value .002) for oropharyngeal airway, 1.14 (p-value <.001) for nasopharyngeal airway, and 0.81 (p-value .003) for bag-mask ventilation.

The median knowledge score, from the 10-item multiple-choice question assessment, increased from 6 for prelearning to 7 for postlearning (p-value .09). There was no significant difference between the pretest and post-test scores between groups 1 and 2 (Table 4). There were missing data from a participant in group 2 who did not complete the postlearning survey. Therefore, the analysis was performed on 47 participants for confidence, stress, and perception level. For confidence level, participants in both groups reported higher confidence after learning in every airway skill (Figure 2). There was no statistically significant difference in postlearning confidence levels between two groups. The stress during the learning sessions was lower in the peer-to-peer group, whereas the participants reported that the standard instructor-led method could increase their knowledge and skills better than the peer-to-peer group (Figure 3).

After each learning session was completed, the participants were asked to choose their preferred method. Thirty-two (69.57%) students chose standard instructor-led teaching as the preferred method (Table 4). The participants were also afforded the ability to add comments after their learning sessions (Figure 4).

**Table 3** The Procedural Checklist Scores Separated by the Learning Method

<table>
<thead>
<tr>
<th>Procedural Skill</th>
<th>Peer-to-Peer N = 24, Mean (95% CI)</th>
<th>Standard N = 24, Mean (95% CI)</th>
<th>p-Value</th>
<th>Effect Size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oropharyngeal airway (max score = 12)</td>
<td>10.42 (9.92-10.91)</td>
<td>8.79 (8.00-9.58)</td>
<td>.002</td>
<td>1.07</td>
</tr>
<tr>
<td>Nasopharyngeal airway (max score = 12)</td>
<td>11.56 (11.21-11.87)</td>
<td>10.38 (9.58-10.9)</td>
<td>&lt;.001</td>
<td>1.14</td>
</tr>
<tr>
<td>BVM (max score = 16)</td>
<td>14.92 (14.71-15.46)</td>
<td>13.67 (12.69-14.31)</td>
<td>.003</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Note: BVM = bag-mask ventilation.

**Table 4** The Knowledge Percentage (10-Item Multiple-Choice Question) and the Number of Students Who Preferred Standard Teaching From the Postlearning Survey

<table>
<thead>
<tr>
<th></th>
<th>Total (N 48)</th>
<th>Group 1 (N 24)</th>
<th>Group 2 (N 23)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prelearning score (median, minimum-maximum)</td>
<td>6 (2-8)</td>
<td>6 (3-8)</td>
<td>5 (2-8)</td>
<td>.13</td>
</tr>
<tr>
<td>Postlearning score (median, minimum-maximum)</td>
<td>7 (2-9)</td>
<td>7 (2-9)</td>
<td>6 (3-9)</td>
<td>.22</td>
</tr>
<tr>
<td>Preferred standard teaching (N, %)</td>
<td>32 (69.57)</td>
<td>17 (53.12)</td>
<td>15 (42.86)</td>
<td>.68</td>
</tr>
</tbody>
</table>

Group 1: oropharyngeal and nasopharyngeal airway skills by the peer-to-peer method and bag-mask ventilation by the standard instructor-led method; group 2: standard instruction for oropharyngeal and nasopharyngeal airway by the standard instructor-led method followed by bag-mask ventilation instruction by the peer-to-peer method.
Discussion

This study demonstrated the potential impact of an innovative teaching method on knowledge, skill (both airway and peer-to-peer instruction), and attitude (confidence). The teaching method combined self-instruction videos, peer-to-peer instruction, guided peer-feedback, and debriefing with the use of the GAS model. This is a modification of what is sometimes described as a blended learning approach with the added innovation of the peer-to-peer instruction and a highly structured self-instruction video and feedback system (Kuszajewski, O'Donnell, Phrampus, Robey, & Tuite, 2016). The skill performance score, knowledge score, and confidence level of the novice nursing students who learned basic airway management by the peer-to-peer method were not inferior to those who had learned by the standard instructor-led method. For the skill assessment score, the peer-to-peer group demonstrated significantly higher scores with a large effect size in every airway management skill category. The combination of the self-study video, peer-assisting learning, and structured debriefing system showed a significant benefit for skill performance. Self-instructed video teaching is effective in establishing psychomotor skills because of the ability to display a moving image (Jang & Kim, 2014). Learners tend to have a deeper understanding and longer-lasting memory with this teaching approach because video can arouse more than one sensory stimulation (Mayer, 2014). Self-instruction videos have been demonstrated to be an effective alternative learning method for cardiopulmonary resuscitation and basic emergency skills for medical students and for baseline skill development for nursing students (Blazeck & Zewe, 2013; Chung, Siu, Po, Lam, & Wong, 2010; Saiboon, et al., 2014). The peer-assisted learning approach has also been demonstrated to improve undergraduate nurse participants’ outcomes in skill
performance, knowledge level, and communication skills (Friel, Kell, & Higgins, 2018; Herrmann-Werner, et al., 2017). Similar to findings in previous systematic reviews and meta-analyses, this study found that students who learned via peer-to-peer teaching methods had no difference in skill learning outcomes compared with those who were taught by standard instructional methods with expert instructors (Rees, Quinn, Davies, & Fotheringham, 2015). Students also have an opportunity to develop their teaching skills in peer-to-peer instructional sessions, which is a ‘value-added’ skill for their future practice. Therefore, the peer-to-peer teaching method should be considered as a valid alternative to standard instruction with the caveat that careful consideration must be taken in development of instructional materials and in quality monitoring. The structured GAS model debriefing method was added to the peer teaching to enhance the student’s ability to give proper feedback. The GAS model is a simple and scalable debriefing method that can be rapidly learned by a novice for the purpose of stimulating peer reflection and debriefing of skill performance. The GAS model enhances learning by providing the student with an opportunity for self-discovery, self-reflection, and knowledge-gap identification (Phrampus & O’Donnell, 2013). Self-reflection has been shown to enhance self-assessment, self-monitoring, and skill performance (Ahmed, 2018).

Peer-to-peer instruction methods were also shown to be noninferior to standard instructor-led methods regarding knowledge and confidence levels. Both methods demonstrated higher knowledge and confidence scores on post-knowledge tests. Approximately 70% of the participants indicated that the standard teaching method was preferred despite our finding that skill attainment was greater after peer-to-peer instruction. Participants reported several advantages to peer-to-peer teaching including less stress and the opportunity to learn through teaching their peer. Furthermore, our results indicate that in future educational sessions, it may be helpful to provide evidence to students from this study and others that carefully constructed peer-to-peer learning experiences can have similar outcomes to instructor-led teaching. This may help alleviate any preconceived negative opinions regarding peer-to-peer instruction.

The standard instructor-led teaching method has some disadvantages. These include the need for high student-to-faculty ratios (in many institutions), the high cost of instructors, and the potential for lack of standardization among instructors. Based on previous online surveys of 833 clinical teachers, the most common challenge for instructors in providing high-quality teaching is lack of adequate preparation time (Schieikirkira-Schwake, et al., 2017). Thus, an added disadvantage is the need for additional and sometimes extensive time committed to instructor preparation. Self-instruction videos and peer-to-peer instruction combined with a guided peer-to-peer structured debriefing feedback model demonstrated significant benefit in teaching basic airway management skills in novice students with minimal preparation time. It also had the significant collateral benefit of reduced cost and decreased instructor workload.

Limitations

This study demonstrated a noninferiority effect for the immediate post—peer-to-peer teaching period. However, the long-term knowledge and skill retention of the participants were not tested. Although this teaching method appears to be highly influential in the retention of knowledge and skills for students in the near term; it has not been tested whether peer-to-peer teaching is noninferior to standard expert teaching in maintaining long-term knowledge and skills. A future study should include and examine this outcome.

Although the peer-to-peer method proved to be effective in teaching basic airway management for novice nursing students, the ability to generalize the method to other skills and participants was not analyzed. It is important to consider that peer-to-peer teaching may only be effective with a certain level of skills and participants. It may not be appropriate to use peer-to-peer teaching for more complex knowledge and skills. It is also recommended that an in-depth analysis and ongoing evaluation of the peer-to-peer teaching course be performed to ensure that the quality of instruction is as intended. Further validation of the self-instruction video is also imperative as it is the main contributor to the standardization of education.

A last limitation is the established culture of the ‘expert instructor’ being the gold standard for educational effectiveness. This is reflected in student perceptions reported in this study that the instructor-led sessions were preferred and in the open narrative comments that indicated this bias (Figure 4). It may be necessary to include evidence-based findings on peer-to-peer instruction in precourse materials to help learners understand that this is a cultural bias and not based on facts.

Conclusion

In conclusion, this study demonstrated novice nursing students who learned basic airway management with the combination of self-instruction videos, peer-to-peer instruction, guided peer-to-peer feedback, and structured debriefing using the GAS model that these methods were not inferior to standard instructional methods in the domains of knowledge, skill, and attitude (confidence). Further analysis revealed higher and statistically significant performance scores for the oral airway insertion, nasal airway insertion, and bag-mask ventilation with large effect sizes for peer-to-peer instruction versus standard instructor-led methods.
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