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DNP Final Project Report
Use of High-Fidelity Simulation Training for New
Cardiothoracic Intensive Care Unit Nurses

Bryan Boling, RN

University of Kentucky
College of Nursing
Spring 2016

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Dedication

This project is dedicated first and foremost to my wife Sarah, my inspiration and my best friend, without whom I'd never be able to have achieved half of what I have in this life. Secondly to my son Caleb and my daughter Molly Kate, who always make me laugh, give me hugs, and remind me why I work so hard each day. I love you all.

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Introduction/DNP Final Project Overview

Critical care nursing is one of the most challenging, high-stress fields in healthcare. Patients are highly complex, often having multiple, competing medical problems, with therapies that may be in direct conflict with each other. The challenge for the critical care nurse is to integrate data from multiple sources, while managing numerous supportive devices, all in an atmosphere where time is critical and decisions that affect the life and death of patients must be made quickly.

This is especially true for nurses in the cardiothoracic intensive care unit (CTICU). The CTICU is a highly specialized environment. Like nurses in the post-anesthesia care unit, CTICU nurses frequently receive patients directly from operating room and monitor them while they recover from general anesthesia. Additionally, there are a variety of devices unique to the CTICU including external temporary pacemakers, intra-aortic balloon pumps (IABP), ventricular assist devices (VAD), or extracorporeal membrane oxygenation (ECMO) that the nurse must manage.

It is well understood and documented in the literature that the experience level of nurses in critical care is positively linked with patient outcomes (Morrison, Beckmann, Durie, Carless, & Gillies, 2001). However, in the current business climate it is becoming more difficult to maintain a high degree of nursing experience in the ICU. Many older nurses are retiring or moving away from the bedside and younger nurses are increasingly moving into advanced practice or management and leadership roles. High stress levels among new graduate nurses may contribute to

early departures from burnout or a desire to seek a position that affords greater opportunities with less stress (Delaney, 2003).

Simulation training has long been used in high-reliability fields such as aviation and nuclear power to provide safe, effective training, and its usefulness has been recognized in healthcare as well (Abe, Kawahara, Yamashina, & Tsuboi, 2013; Kaddoura, 2010b; Kane, Pye, & Jones, 2011). It is even possible that advanced training techniques such as simulation could make up for deficiencies in clinical experience and reduce the stress levels of newer ICU nurses. The purpose of this project is to examine the use of simulation training in critical care, specifically with respect to its ability to improve learning and confidence among critical care nurses; to design and implement a simulation training course for new graduate nurses in the CTICU; and to evaluate the effect of that program on the knowledge and confidence levels of new CTICU nurses.

The Effect of High-Fidelity Simulation on Knowledge and Confidence in Critical Care
Training: An Integrative Review

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Abstract

Patient outcomes in critical care have long been linked to provider experience, but with older providers retiring, it is becoming difficult to maintain a high level of experience among ICU staff. Innovative training methods that improve providers' knowledge and confidence may be able to make up for deficiencies in clinical experience. High-fidelity simulation training mimics clinical experience and has been extensively studied in the training of procedural skills, but what is the effect of this type of training on knowledge and confidence? To answer this question, a review of the literature was conducted for studies examining the effect of simulation training on knowledge and confidence among critical care providers. Seventeen papers were identified that met the inclusion criteria and a systematic approach was used to review the papers and synthesize the data. All 17 studies demonstrated an improvement in knowledge and while only 13 of the included studies examined the effect on provider confidence, all found an improvement. In conclusion, high-fidelity simulation is a useful tool for improving knowledge and confidence among critical care providers and merits consideration for inclusion in critical care training programs.

The care of the critically ill patient represents one of the most challenging tasks in modern healthcare. Patients in the intensive care unit (ICU) often have multiple simultaneous medical problems that may require widely divergent management strategies, necessitating a fine balance between therapies. Data from monitors, laboratory tests, and other examinations must be synthesized to form a cohesive understanding of the problem so that clinical knowledge can be applied to address the issues. In addition, time is often of the essence and patient conditions may change rapidly, necessitating efficient diagnostic reasoning and evidence-based management.

Experience on the part of critical care providers (physicians, nurse practitioners [NP], physician assistants [PA], and nurses) in dealing with critically ill patients and situations has been shown to improve patient outcomes (Morrison et al., 2001); however, with many older providers retiring and turnover of younger providers increasing, it has become difficult to maintain a high level of experience among ICU staff (AMN Healthcare, 2013). Therefore, it is essential to ensure the highest quality training possible for ICU providers, both during the initial training period and through continuing education. Even in the busiest ICUs, it is unlikely that trainees will be exposed to all possible clinical scenarios. Simulation in critical care training ensures that any specific scenario may be encountered by the trainee, and may be carried out in a safe environment without putting patients at risk (Hovancsek, 2007).

The term “simulation” may be widely applied and includes the use of standardized patients, computerized manikins, and animations (Institute of Medicine [IOM], 2010). High-fidelity simulation is a specific form of simulation that utilizes lifelike manikins, which are able to faithfully reproduce physiological conditions of illness or injury and response to treatments and interventions (Decker, Sportsman, Puetz, & Billings, 2008). For the purposes of this paper, the term “simulation” refers exclusively to high-fidelity simulation unless otherwise specified.

A number of studies have shown simulation to be an effective tool for training in healthcare and it has been used in a variety of disciplines including critical care (Roche, 2010), trauma (Harvey, Wright, Taylor, Bath, & Collier, 2013), obstetrics (Gardner & Raemer, 2008), and surgery (Cumin, Boyd, Webster, & Weller, 2013). Its use has been shown to improve patient safety and operator skill in the performance of procedural skills including central venous catheterization, airway management, colonoscopy, peripheral venous cannulation, and bladder irrigation (Zendejas, Brydges, Wang, & Cook, 2013). In addition to technical skill training, simulation is increasingly utilized as a tool for improving clinical knowledge and provider confidence/self-efficacy.

The Review

Aim

The purpose of this integrative review is to examine the current research in order to answer the primary research question: “What is the effect of high-fidelity simulation on the knowledge and confidence/self-efficacy of critical care

providers?” Although the conclusions of other authors reached through integrative and systematic reviews are no doubt beneficial, we chose to proceed with a review exclusively of original research. Based on this review, gaps in the current literature will be identified and areas for future research addressed.

Search Methods

A comprehensive search for original, peer-reviewed research studies published in English within the past 10 years was performed using the following search string: “(simulation”) AND (“critical care” OR “intensive care”). The search was conducted using both the Cumulative Index to Nursing and Allied Health Literature (CINAHL) and the Medical Literature Analysis and Retrieval System Online (MEDLINE) databases.

Studies were included in this review if they were original research involving nurses and/or physicians in critical care and the use of high-fidelity simulation and its effect on knowledge and/or confidence. Studies using simulation modalities other than high-fidelity manikins, focusing on the training of procedural skills, and review papers were excluded from this review (see Table 1). Titles and abstracts of all search results were reviewed and inclusion and exclusion criteria applied. All references cited in extracted articles were further reviewed for potential relevancy. Each article selected was examined and graded according to the American Association of Critical Care Nurses (AACN) Levels of Evidence (Table 2; Armola et al., 2009). The selected articles are summarized in Table 3.

Results

The initial search returned 1453 papers (349 from CINAHL and 1104 from MEDLINE). After duplicate papers were removed and inclusion criteria applied to a reading of titles and abstracts, 25 papers remained. Further review of the entire papers excluded an additional 8, leaving 17 papers for inclusion.

Of the 17 papers included, six were graded at a Level B and the remaining 11 at a Level C. Nine of the studies were conducted using physicians (either in training or practicing) as subjects, five used registered nurses, and three were either a mixed physician/nurse (n=2) or NP/PA (n=1) population. Sample sizes of the studies ranged from three to 102 with a mean sample size of 30 (SD = 26.7). The majority of studies were conducted in the United States (n=12), with the remainder conducted in Canada (n=2), Japan (n=1), Sweden (n=1), and Finland (n=1). The majority of studies (n=12) assessed the effect of simulation on knowledge as well as provider confidence. Four studies (Plante, 2006; Schroedl et al., 2012; Singer et al., 2013; Springer et al., 2013) only examined the effects on knowledge; one (Meurling, Hedman, Sandahl, Felländer-Tsai, & Wallin, 2013) only examined the effect on confidence. Several studies examined variables other than knowledge and confidence; however, for the purposes of this review, the focus only on the results in those two areas.

Effect on Knowledge/Competence

Sixteen studies measured the effect of simulation on the participants' knowledge and/or perceived clinical competence. The largest group of studies (n=7) measured the effect of the simulation using a self-assessment on the part of the

participant. In all seven studies (Abe et al., 2013; Figueroa, Sepanski, Goldberg, & Shah, 2013; Kaddoura, 2010b; Kane et al., 2011; Lavoie, Pepin, & Boyer, 2013; Nishisaki et al., 2009; Willett, Kirlew, Cardinal, & Karas, 2011), participants rated their own perception of their knowledge as greater following the simulation intervention.

Six studies used some variation of objective testing with a control group for comparison. Of these, three studies (Jansson et al., 2014; Springer et al., 2013; Tofil et al., 2011a) utilized a pre-test/post-test model for the intervention group and compared the results to the same test taken by the control group. In two studies (Jansson et al., 2014; Tofil et al., 2011a), participants in the intervention group improved their scores following the simulation exercise. Further, scores in the intervention groups were consistently higher than those in the control groups who did not participate in the simulation exercise.

In a slight variation, both groups in one study (Springer et al., 2013) received simulation training; however, one group conducted all of their scenarios in one session while the other group divided the three scenarios over three days. Overall scores improved from 75% to 81%, but only the group with multiple sessions showed statistically significant improvement.

The remaining three studies (Pascual et al., 2011; Schroedl et al., 2012; Singer et al., 2013) did not include a pre-test, only a post-test following the intervention. Two studies (Schroedl et al., 2012; Singer et al., 2013) examined the use of simulation in training medical residents and found that objective test scores increased following the simulation. Interestingly, Singer et al. (2013) compared

first-year residents with no ICU experience to experienced third-year residents and found that prior experience had less effect than the simulation. Prior to a month-long ICU rotation, the inexperienced group completed a simulation course while the experienced group did not. Following the rotation, both groups were tested on their clinical knowledge, with the inexperienced group outperforming the experienced group 91.3% to 80.9%. Again, the intervention group outperformed the control group in all studies.

Pascual et al. (2011) examined the effect of simulation on knowledge among NPs and PAs. Participants completed a simulation exercise regarding management of common surgical ICU emergencies with a multiple-choice test administered both before and after. Following the simulation, test scores increased by 5%. This study utilized recently graduated surgical critical care fellows as the control group. In this instance, the control group also participated in the simulation exercise, but did not show any improvement in scores.

Three studies (Antonoff, Shelstad, Schmitz, Chipman, & D'Cunha, 2009; Musacchio et al., 2010; Plante, 2006) conducted a pre and posttest model, but without a control group for comparison. All studies showed an improvement in test scores following the simulation exercise. In an evaluation of surgical interns, Antonoff et al. (2009) found that performance on a multiple choice test of general critical care knowledge improved by 43% following three sessions of simulation scenarios involving common surgical emergencies in the ICU. Similarly, Musacchio et al. (2010) found an average increase of 25% in a group of neurosurgery, neurology, and general surgery residents on a neurocritical care test, with general

surgeons experiencing the greatest increase (38%). In another study, Maternal-Fetal Medicine fellows completed a critical care simulation course and improved test scores from a mean of 30% prior to the course to a mean score of 69% afterwards (Plante, 2006).

Effect on Confidence

Twelve of the 17 included studies assessed the effect of simulation on provider confidence. Again, self-assessment on the part of the participant following the simulation was the most common form of measurement (n=7). In all seven of these studies (Abe et al., 2013; Figueroa et al., 2013; Kaddoura, 2010b; Kane et al., 2011; Lavoie et al., 2013; Nishisaki et al., 2009; Willett et al., 2011), participants stated that they were more confident in their ability to manage critically ill patients following participation in the simulation exercises.

The remaining five studies used an objective tool to measure confidence. Three of these utilized a control group for comparison (Jansson et al., 2014; Pascual et al., 2011; Tofil et al., 2011a). In their comparison of NPs/PAs to physician critical care fellows, Pascual et al. (2011) found that confidence for the NP/PA group increased by 8% following the simulation exercise, whereas the confidence scores for the fellows did not increase.

Meurling et al. (2013) did not use a control group; instead, they used a pre and posttest model with a single group. A validated self-efficacy assessment tool was used to evaluate the effect of a group simulation exercise on the confidence of physicians, nurses, and nursing assistants in a large Swedish ICU using. Self-efficacy scores for both nurses and physicians rose following the exercise.

Antonoff et al. (2009) likewise did not use a control group; however, in this study, only a post-scenario assessment of self-efficacy was conducted. All participants rated their confidence as a result of the simulation scenarios as high. The average score was 4.24 out of a possible five points.

Discussion

Application of Clinical Knowledge

One of the more difficult challenges facing novice practitioners is assimilating all of the knowledge gained in education and training and applying it to real life patient care scenarios. Experiential education is an integral component in the training of physicians, nurses, NPs and PAs through the clinical rotations in their respective educational programs. Similarly, postgraduate residency and fellowship training is a mainstay of physician education and its importance to nursing education is now being recognized with the development of similar postgraduate programs for nurses and NPs.

Experience offers repetition, which helps to cement learning. Abe et al. (2013) and Springer et al. (2013) found that knowledge increased with multiple simulation sessions. This underscores the importance of repetition and may indicate that simulation sessions should be repeated multiple times, although the precise details as to length and frequency of sessions for optimal learning are unclear.

Simulation seems ideally suited for training in situations that are rare in actual practice, but where a high level of performance is essential (Fernandez et al., 2010; Kane et al., 2011; Musacchio et al., 2010). In the simulation of these high-risk, low-frequency events, staff can become comfortable dealing with situations that

may arise so infrequently in actual practice that clinical experience ceases to confer any significant benefit. Additionally, these scenarios can be practiced in a risk free environment where no harm will come to patients during the learning process.

Beyond training in high-risk scenarios, simulation also seems beneficial for training in the more everyday aspects of critical care (Antonoff et al., 2009). Just as in the simulation of rare emergencies, simulation allows trainees to role-play various common complications, increasing their understanding of and ability to apply learned knowledge. This repeated exposure to clinical situations allows trainees to hone their critical thinking skills, leading to improved clinical judgment.

When compared to more traditional educational methodologies such as lectures or reading assignments, simulation seems to demonstrate superiority in preparing practitioners. Simulation has been shown to improve critical thinking skills and overall clinical decision-making to a greater degree than more conventional methods (Lewis, Strachan, & Smith, 2012). For example, Schroedl et al. (2012) found that medical residents who received training using simulation performed better on a checklist-based bedside skills assessment than their colleagues who received training through lectures alone. This has definite implications for the way that we approach the training of critical care nurses. Many nurses may receive lectures or use self-paced teaching modules such as the Essentials of Critical Care Orientation (ECCO; American Association of Critical Care Nurses, 2014) during their orientation and as part of their continuing education. While these programs are effective for the development of critical thinking and understanding of the care of the critically ill patient (Kaddoura, 2010a), simulation

sessions appear to offer an even greater benefit and their inclusion in training programs should be considered.

Several studies (Musacchio et al., 2010; Pascual et al., 2011; Plante, 2006) found that simulation was particularly effective in training novices. In a study of simulation training in neurocritical care (Musacchio et al., 2010), all participants experienced an increase in test scores; however, the general surgery residents, who were least likely to be well-versed in neurocritical care, saw the greatest increase. Similarly, Maternal-Fetal Medicine fellows, who receive very little critical care training, saw substantial increases in scores following the simulation exercise. Even though the final scores were still not what would be considered a passing score on a board exam, the increase demonstrates the potential for simulation training in improving clinical knowledge, especially in a population with such limited prior exposure to the field.

Not only is simulation better than traditional teaching methods at facilitating application of knowledge to practice, there is evidence to suggest that the use of simulation may be superior to actual patient care experience. In their study of inexperienced vs. experienced medical residents, Singer et al. (2013) demonstrated that the use of simulation could help inexperienced residents to outperform their colleagues who relied on their clinical experience alone. Given the fact that patient outcomes improve with provider experience (Morrison et al., 2001), this has profound implications for critical care nurse training. As retention of older nurses continues to be an issue and nurses spend fewer years at the bedside gaining clinical

experience, the use of simulation exercises may be a valuable tool to help elevate the level of skill and knowledge among an increasingly less experienced workforce.

Provider Confidence

The studies reviewed demonstrate that the use of simulation can increase confidence on the part of the provider. Willett et al. (2011) found that a simulation course for family practice residents increased confidence on the part of the residents to deal with critically ill patients, a population to whom these residents received little to no exposure in training. Likewise, Pascual et al. (2011) found that a simulation course dealing with critical care emergencies not only increased knowledge among NPs, but also improved their confidence to deal with such emergencies independently.

However, confidence and competence should not be confused, and the two are not always synonymous (Mould, White, & Gallagher, 2011). For example, in their study on the use of a simulation exercise for pediatric residents in the pediatric intensive care unit (PICU), Tofil et al. (2011a) found that confidence in participants' abilities did not always equate to an actual improvement in their performance. Trainees were videotaped and their performances reviewed by independent experts. Participants were asked to rate their comfort level and confidence in dealing with PICU emergencies before and after completing the course. Although all participants reported an increase in confidence and comfort level, objective assessment failed to demonstrate any significant improvement in ability. This should underscore the importance of understanding that simulation has the ability to increase confidence on the part of the trainee through simple repetition without

increasing actual ability. Both confidence and ability should be assessed in any simulation training program.

Critique of Available Evidence

The major limitations of all studies are summarized in Table 3. Three major limitations are present in the majority of included studies: small sample size, lack of a control group or disparity between the study groups, and the lack of objective measurement tools to assess the outcomes.

Given the realities of simulation training, including the cost and time involved in operating a simulation laboratory, it is understandable that these studies are small in size. Although few large randomized trials have been conducted, this review demonstrates that a number of similar, smaller trials conducted in different settings have yielded similar results. This consistent replication of outcomes therefore lends additional weight to the studies' conclusions.

The majority of studies did not utilize a control group, so it is difficult to say with certainty that the results obtained were not due to chance or to the unique characteristics of the study participants. However, many studies did attempt to control for this, specifying uniformity on the part of the participants with respect to educational background and prior experience, both clinically and with simulation.

Some studies did utilize control groups; however, they were frequently not randomly assigned and in many cases, not comparable. In some cases, this disparity was intentional and actually lent weight to the studies' conclusions. Three studies (Singer et al., 2013; Springer et al., 2013; Tofil et al., 2011a) all used simulation to show that the intervention group outperformed the control group, despite the fact

that the control group was more experienced, thus leading us to the conclusion that simulation may in fact be a better training tool than actual clinical experience. This is likely due to the fact that experience among providers may vary greatly while simulation offers uniformity and the opportunity to ensure that certain scenarios are included in the training process.

Limitations

Limitations of this integrative review include the search terms selected and the restriction to the use of studies published in the English language. Search terms were chosen for the breadth of content they were likely to return. Additionally, the fact that many studies did not specify the simulation modality in the title or abstract made narrowing the search difficult without potentially excluding articles of interest.

Areas for Future Research

Although it is clear that simulation can improve knowledge and confidence in critical care, there are a number of areas for further research and study. One problem identified through this review is the paucity of large, randomized controlled trials of simulation training in critical care nursing. Many of the conclusions drawn in this paper are based on the experiences of physicians. It would be interesting to examine, for instance, if simulation could make up for the deficiencies in experience between an experienced ICU nurse and a recent graduate in the same way that it has been shown to between novice and experienced resident physicians.

Perhaps the largest area for further study is in addressing whether the use of simulation in critical care training improves patient outcomes. Research supports the idea that increased knowledge and experience on the part of providers leads to improved patient outcomes (Morrison et al., 2001), and this review supports the idea that simulation training leads to increased knowledge and experience. The inference could be made, therefore, that simulation training would lead to improved outcomes; however, there is little conclusive data to support that claim. So far, studies of simulation training in critical care have been conducted in relative isolation, focusing only on the educational objectives. Further study is needed to connect simulation training to patient outcomes.

Another factor to consider is the cost-effectiveness of simulation training. While it is an effective training tool and popular among participants, simulation is a potentially costly endeavor (Hanberg, Brown, Hoadley, Smith, & Courtney, 2007; Lapkin & Levett-Jones, 2011). In the current market, it is important to allocate financial resources in a manner to optimize the benefit received. If simulation training leads to improved patient outcomes, can these improved outcomes result in a reduction in healthcare spending sufficient to offset the cost of the training?

Conclusion

Critical care is a challenging environment that involves the integration and synthesis of knowledge and data from numerous sources and rapid assessment and decision-making. Provider experience has been demonstrated to be a positive factor in patient outcomes, but with the predicted shortfall in experienced ICU providers, additional training methods must be identified to compensate for a lack of

experience (AMN Healthcare, 2013). Simulation has been shown to be effective at improving clinical knowledge and provider confidence in critical care environments. In some cases, training with simulation has been shown to be more effective than actual patient care experience. Integration of simulation into provider training and continuing education seems to be an excellent solution to the problem of the increasing complexity of critical care combined with the relative inexperience of today's providers.

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Table 1

Inclusion and Exclusion Criteria

Inclusion Criteria

- Use of high-fidelity simulation
- Research study
- Effect on confidence and/or knowledge
- Nurses and/or physicians

Exclusion Criteria

- Exclusive training of procedural skills
- Simulation modalities other than high-fidelity manikin
- Reviews

Table 2

AACN Levels of Evidence (LOE)

LOE	Examples
Level A	Meta-analysis of multiple studies with consistent results
Level B	Single studies with consistent results
Level C	Qualitative, descriptive or correlational studies; integrative or systematic reviews; randomized controlled trials with inconsistent results
Level D	Peer-reviewed professional organizational standards supported by clinical studies
Level E	Theory-based evidence (i.e. expert opinion, case studies, consensus statements)
Level M	Recommendations of product manufacturer

Adapted from "AACN levels of evidence: what's new?" by R.R. Armola, et al., 2009, *Critical Care Nurse*, 29(4), p. 7

Table 3

Summary of Included Articles

Study	Design	Sample Size	Summary of Findings	Limitations	LOE	Population	Country
Abe et al. (2013)	Prospective	24	Nurses in cardiovascular critical care participated in 4 simulation scenarios and were scored according to a predefined rubric. Debriefing sessions followed each scenario. All participants improved in both competence and confidence following each scenario and debriefing. Further, continued improvement was seen as participants completed more scenarios.	Small sample size; lack of a control group	C	Nurses	Japan
Antonoff et al. (2009)	Prospective	15	Surgical interns completed a 3 session simulation course covering common surgical emergencies in the ICU. Pre and post intervention multiple choice question knowledge tests were administered, as was a post-intervention feedback form to assess confidence. The average participant experienced an average increase of 43% on the multiple choice question test. The average score for confidence was 4.24/5.	Small sample size; lack of a control group; low internal consistency reliability of multiple choice question test	C	Physicians	USA
Figueroa et al. (2013)	Prospective	37	Physicians in training (n=5), nurses (n=23), respiratory therapists (n=5) and other non-categorized personnel (n=4) from both the general PICU and pediatric cardiac ICU participated in simulation scenarios involving pediatric resuscitation. Participants were asked to rate their	Small sample size; lack of a control group; no objective measurement of competence using validated tool, only participant's self-	C	Mixed	USA

			perceived competence and confidence using a Likert-type scale before the intervention, immediately afterwards, and at 3 months. All participants reported increase in both confidence and perceived competence following the intervention. Scores further increased (by a lesser degree) at three months.						rating.
Janssen et al. (2014)	RCT	30	ICU nurses participated in a simulation scenario related to care of the mechanically ventilated patient. Nurses were randomly assigned to an intervention group that received feedback and debriefing and a control group that did not. Pre- and post-tests were administered using validated instruments to test knowledge of ventilator bundles to prevent ventilator associated pneumonia (VAP). Scores for the intervention group increased significantly following the simulation exercise.	Small sample size.	B	Nurses	Finland		
Kaddoura (2010)	Qualitative	10	New graduate nurses in the ICU participated in various simulation scenarios common to the ICU and a debriefing session afterwards. All participants reported an increase in confidence and knowledge.	Small sample size; lack of a control group; no objective measurement of confidence or competence, only participant's self-rating	C	Nurses	USA		

Kane et al. (2011)	Prospective	64	Pediatric cardiothoracic ICU nurses participated in simulation resuscitation scenarios. Statistically significant improvement in participant ratings of confidence and comfort with knowledge of resuscitation procedures.	No objective measurement of competence with validated tool, only participant's self-rating; lack of a control group	C	Nurses	USA
Lavoie et al. (2013)	Qualitative	5	New graduate nurses in the ICU participated in a simulation scenario and group debriefing. All participants reported initially feeling like they had failed the scenario, but following debriefing their confidence in their abilities increased and they were able to identify gaps in their own knowledge that needed focused attention.	Small sample size; lack of a control group; no objective measurement of confidence or competence, only participant's self-rating	C	Nurses	Canada
Meurling et al. (2013)	Prospective	102	Physicians (n=30), nurses (n=53), and nursing assistants (n=19) all participated in 5 simulation scenarios of emergencies in the ICU. Participants completed a validated self-efficacy assessment tool before and after the scenarios and debriefing sessions. Self-efficacy scores for both physicians and nurses increased significantly following simulation sessions.	Relatively small sample size when broken out into professional role; lack of a control group	C	Mixed	Sweden
Musacchio et al. (2010)	Prospective	29	Neurosurgery residents (n=8), general surgery residents (n=4), neurology residents (n=14), and senior medical students (n=3) participated in various simulation scenarios common in neurocritical care. Each participant completed a multiple choice question test of knowledge before and after the intervention. Average scores increased by 25% with general surgery residents and	Small sample size; lack of control group	C	Physicians	USA

medical students showing the greatest improvement at 38% each.

Nishisaki et al. (2009)	Prospective	24	Pediatric Critical Care fellows (n=22), pediatric hospitalist (n=1), and pediatric emergency medicine fellow (n=1) participated in a 2.5-day simulation course covering common scenarios in pediatric critical care. Following the course, participants rated the course effectiveness and their own levels of improvement in confidence and clinical performance. All participants rated their improvement in both confidence and clinical performance as high (mean Likert score >4 out of 5)	Small sample size; lack of a control group; no objective measurement of competence using validated tool, only participant's self-rating. No pre-test comparison.	C	Physicians	USA
Pascual et al. (2011)	Non-randomized control trial	12	NPs and PAs participated in 5 simulation scenarios of uncommon, but not rare emergency events encountered in the ICU. A group of 4 recently graduated critical care fellows was used as a control group. All participants completed a multiple choice question test of knowledge related to the various scenarios and a validated questionnaire assessing confidence levels before and after the simulation and debriefing sessions. NP/PA scores on the multiple choice question improved by a statistically significant 5% and confidence scores by a statistically significant 8% whereas the fellows' scores did not improve at all.	Small sample size	B	Mixed	USA
Plante et al. (2006)	Prospective	3	MFM fellows participated in a yearlong critical care course including lectures and simulation. Score on multiple choice question test of critical care knowledge	Small sample size; lack of control group; course included lectures given over a	C	Physicians	USA

improved from 30% to 69%

year in addition to simulation

Schroedl et al. (2012)	RCT	60	First-year medical residents in the MICU were randomized into an intervention group that completed a 4-hour simulation training session prior to the MICU month and a control group that did not. At the end of the MICU month, each resident was assessed using a validated tool of critical care knowledge. The intervention group scored significantly higher than the control group.	The intervention group received some extra didactic training during the simulation sessions, which may partially account for increase in scores	B	Physicians	USA
Singer et al. (2013)	Non-randomized control trial	67	First year residents (n=40) with no prior MICU experience participated in a simulation training session prior to their MICU rotation. Third year residents with MICU experience (n=27) served as the control group. Both were tested at the end of their MICU rotation using an objective 20-item assessment tool regarding knowledge of management of the mechanically ventilated patient. The intervention group outscored the control group (91.3% vs. 80.9%)	No pre-test to evaluate change as a result of simulation	B	Physicians	USA
Springer et al. (2013)	Non-randomized control trial	60	First year surgery residents (n=15) were grouped into the single-simulation exposure (SSE) group, while a second group was composed of a combination of first year surgery residents, second or third year anesthesiology residents, and second year emergency medicine residents (n=45). The second group was termed the multiple simulation exposure (MSE) group. Each group participated in 3 30-minute	Unequal study groups; no randomization	B	Physicians	USA

simulation shock scenarios. The SSE group completed all scenarios in a single session, while the MSE group completed 1 per day over 3 days. Both groups completed a multiple choice question test of knowledge before and after the completion of the simulation. Overall scores improved (75% vs. 81%); however subgroup analysis showed significant improvement only for the MSE group.

Tofil et al. (2011)	Non-randomized control trial	34	Second year pediatrics residents (n=16) participated in a series of 6 simulation scenarios of common pediatric critical care emergencies and surveyed regarding their confidence and perceived competence in managing such scenarios before and afterwards. Third year pediatrics residents (n=18) served as the control group. Confidence and perceived competence on the part of the intervention group both increased significantly following the intervention. Post intervention confidence and perceived confidence were both significantly higher than the control group.	Small sample size; lack of randomization	B	Physicians	USA
Willet et al. (2011)	Prospective	37	Family Medicine residents completed a 2-day course on managing the critically ill patient including the use of simulation. All agreed that it increased their confidence and competence in the management of critically ill patients.	Small sample size; lack of control group; no objective measurement of confidence or competence using validated tool, only participant's self-rating.	C	Physicians	Canada

LOE – Level of Evidence; RCT – Randomized Control Trial; NP – Nurse Practitioner; PA – Physician Assistant

Implementation of a High-Fidelity Simulation Training Program for New
Cardiothoracic ICU Nurses

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The transition from nursing student to professional nurse brings with it the possibility of high levels of stress and anxiety for those stepping into that role for the first time. The challenges of adapting to a new role and of applying theoretical knowledge to practical situations, coupled with low levels of self-confidence experienced by the new graduate nurse may all contribute to this stress (Delaney, 2003). This is particularly true for nurses in the cardiothoracic intensive care unit (CTICU) due to the additional knowledge required and equipment that must be managed in the hours immediately following cardiac surgery. All of this makes the orientation of new graduate nurses in the CTICU difficult.

The objective of this pilot study was to design and implement a high-fidelity simulation training program as part of a new graduate nursing internship in the CTICU of a 900-bed university hospital in the southeastern U.S. Many other high-reliability fields including aviation and nuclear power have had success in incorporating high-fidelity simulation into their training programs, and its use has likewise been shown to be beneficial in healthcare (Abe et al., 2013; Kaddoura, 2010b; Kane et al., 2011).

Internship programs for new graduate nurses were developed to help aid the transition from classroom to clinical practice (Herdrich & Lindsay, 2006). Our CTICU has a six month internship pairing new graduate nurses with experienced preceptors. In addition to the standard preceptorship, the internship incorporates didactic instruction on a variety of topics related to the CTICU; however, simulation training has not previously been included.

Design

Framework

The framework chosen to guide the implementation of the simulation class was the Nursing Education Simulation Framework (Jeffries, 2005). This framework focuses on five essential components of simulation training: teacher factors, student factors, educational practices, scenario design characteristics, and outcomes evaluation.

Teacher Factors. Unlike traditional classroom lectures, simulation instruction is centered on the student. However, the teacher is an essential component. In simulation training, the teacher may function either as a facilitator, guiding the scenarios and using them as a vehicle with which to teach, or as an evaluator, monitoring the students to assess their abilities and/or knowledge (Jeffries, 2005). The purpose of the simulation class was educational rather than evaluative. The role of instructor was that of facilitator, not evaluator. To that end, students were allowed to interrupt and “pause” the scenario to ask questions. The instructor was also allowed to “pause” the scenario in order to clarify a point or to teach a concept, particularly if the student seemed to be struggling.

Student Factors. Students in simulation classes need to be somewhat responsible for their own learning as the focus of the class is on the student rather than the teacher (Jeffries, 2005). In the design and implementation of a simulation class, it is important to take into account various student factors including demographics and pre-class knowledge and abilities. The students in this class were

all new graduate nurses, the majority of whom held Bachelor of Science in Nursing degrees.

Timing was another student-related factor in this study. This was important because the class needed to occur early enough in the internship process to be of benefit in later clinical situations, but late enough so that new nurses would have had time to acclimate to the role of ICU nurse. It was important for the participants to have enough basic knowledge and experience that the exercise would not result in undue frustration.

It was decided that the class should take place 8-10 weeks into the internship program. This time frame would allow the participants to begin to have some independence in the role of professional nurse and to become accustomed to the basic environment of the CTICU. By this point, the nurses would also have had didactic classroom instruction in advanced hemodynamics, including pulmonary artery catheter data, calculation of systemic vascular resistance, and understanding of what all of these data mean in terms of the patient's hemodynamic status.

Because of the graduated responsibility of the internship program, none of the participants would have direct, hands-on experience in the care of the patient in the immediate post-operative period. This was important in order to remove the possibility of clinical experience as a confounder.

Educational Practices. Jeffries (2005) has identified a number of educational practices that are essential to the successful implementation of a simulation training program. These include active learning, feedback, student-faculty interaction, and collaborative learning. Many of these are inherent in

simulation based learning. As a participant in the simulation scenario, the student becomes an active learner. As mentioned earlier, simulation learning places the student at the center; the student is required to be engaged, not sit passively and listen to a lecture.

Feedback is obtained both from the instructor and the simulator itself. The computerized manikin is programmed to respond in certain ways according to the scenario. In this way, if the student makes an incorrect choice of action, the patient will continue to deteriorate rather than improve.

As discussed above, the students were allowed to ask questions of the instructor. In this way, there was a degree of student-faculty interaction that would not be present if the instructor was a passive observer. In addition to asking questions of the instructor, participants were allowed to ask questions of their fellow interns in the room. This was allowed in order to encourage group discussion to facilitate learning as well as to mimic the real-life environment of teamwork employed in the CTICU.

Scenario Design Characteristics. When designing simulation scenarios, it is important to focus on targeted competencies (Boulet & Murray, 2010). It was decided all of the scenarios would be focused around a consistent theme important to CTICU nursing. A number of researchers have reported on the use of expert panels in the design and validation of simulation scenarios (Shelestak & Voshall, 2014; Waxman, 2010); experienced CTICU nurses were asked about the major issues they felt were most important in the management of post-cardiac surgery patients. During the course of this discussion, these nurses were also asked what

situations they found most challenging when they were novice nurses. A discussion with preceptors in the CTICU identified situations or topics they felt consistently challenge or intimidate the new nurses they are precepting. From these discussions, it was determined that all the scenarios would be related to the care of the post-operative cardiac surgery patient with low blood pressure and/or low cardiac output immediately following surgery.

Once the theme was established, specific situations were selected. Again, the selection was made in consultation with a group of experienced nurses and this time included input from physicians from the Department of Anesthesiology, Division of Critical Care Medicine (CCM), who provide intensivist coverage for the CTICU. The physician input was sought in order to add an additional level of expertise in the design of specific scenarios. Three broad categories were selected: the need for blood transfusion vs. crystalloid/colloid infusion, the need for inotropic agents vs. vasopressors, and dealing with an acute protamine reaction.

Before writing specific scenarios, it is important to be familiar with the type of equipment to be used and the technical limitations of that equipment (Boulet & Murray, 2010). This will eliminate the possibility of writing a scenario that requires a function that the simulator is unable to produce. If such functionality is absolutely necessary, now is the time to design an alternative strategy (e.g. use of a white board to display data that the simulator cannot). While this may detract from the realism of the scenario, it must be decided if inclusion of the scenario outweighs the lack of fidelity that may result.

Four specific scenarios were written by the authors. Each of these scenarios was then validated by a group of experienced CTICU nurses and CCM physicians to ensure the accuracy of the patient presentation with respect to vital signs, signs and symptoms, and reactions to possible interventions. Each scenario was then further compared to the available literature regarding the standard of care and any applicable guidelines for treatment of the complications (O'Brien, Hagler, & Thompson, 2015).

The first step in writing each scenario was to identify defined objectives (Adamson & Prion, 2012; O'Brien et al., 2015). Defined objectives are important in order to provide an objective standard by which to determine the proper overall performance of the student (Jeffries, 2005). Then, a checklist of expected decisions or tasks was created as an objective way of assessing performance. It is important to note that these scenarios were designed to teach the participants rather than to test their knowledge; however, even in a teaching situation, it is important to have an objective way to measure performance so that potential areas for improvement may be identified as part of the debriefing process. The participant may achieve the objectives, but it is also important that they understand how they achieved them, and to teach them how to think through the problem in a stepwise fashion.

Perhaps one of the most important aspects of simulation training is the debriefing following a scenario (Jeffries, 2005; Levett-Jones & Lapkin, 2014). Although often overlooked, debriefing offers some of the best opportunities for learning in the entire simulation training process. Debriefing offers a chance to reflect on what was done well, what was missed, and to discuss strategies for future

improvement. Additionally, this is a time when the instructor can further explain any new or poorly understood concepts covered in the scenario.

Outcomes Evaluation. Important in the implementation of any new program is its evaluation (Jeffries, 2005). Evaluation of the program can help to refine the scenarios, improve the teaching style of the instructor, and guide further development of the program. For this simulation class, we used the Simulation Evaluation Tool (SET; Elfrink Cordi, Leighton, Ryan-Wenger, Doyle, & Ravert, 2012). The SET is a validated 13-item questionnaire using a 0-2 Likert scale with higher scores indicating greater perceived effectiveness.

Implementation

Equipment and Setting

A modern simulation center, complete with manikins, monitors, white boards, and a full-time simulation specialist was used for this project (Figures 1 and 2). Once the scenarios were written and validated, the simulation specialist programmed all of them into the simulator and ran the simulation equipment during the class. This allowed the instructor to focus on facilitating the scenario and teaching. A white board was placed near the head of the patient manikin and was used by the teacher to display laboratory data, intake and output totals, and any other relevant information for ready availability by the student.

In order to facilitate learning and to accommodate the physical space available in the simulation laboratory, the overall group of interns was randomly divided into two small groups. Each of the nurse interns completed a scenario as the

primary nurse. The order in which the interns proceeded was by volunteer and a scenario was selected at random.

Debriefing

Following each scenario, the group as a whole engaged in a debriefing session led by the instructor. The participant was first allowed to discuss how they felt about the scenario, and to analyze their own strengths and weaknesses. The, other members of the small group were allowed to offer input of their own. Finally, the instructor offered feedback based upon observations as well as the participant's completion of defined objectives and performance on the checklist of expected tasks. This was done deliberately in order to allow for feedback that was free of influence from any source that may be regarded as more authoritative.

Evaluation

Oral feedback from the participants was very positive. All participants expressed that they enjoyed the experience and felt that it was valuable to their learning and that participating in the simulation class was more beneficial than listening to a lecture on the topic would have been. This is consistent with previous studies comparing simulation to more traditional teaching methodologies (Lewis et al., 2012; Schroedl et al., 2012). The results of the SET validated the oral feedback. The results ranged from 1.46 to 2.0 with a mean of 1.64 (SD=0.56), indicating a high degree of perceived effectiveness.

Discussion

The use of high-fidelity simulation in the training of new ICU nurses has enormous potential. It is important that an educational framework as is described

here be used to ensure optimal learning. Simulation has been widely studied in various fields including aviation, nuclear power, and healthcare. It has been found repeatedly to be an effective training tool, perhaps offering even more benefits than clinical experience (Singer et al., 2013). The benefits of simulation training have been shown to be particularly pronounced among novice learners (Musacchio et al., 2010; Pascual et al., 2011; Plante, 2006).

One potential barrier to the use of this type of training is cost. Not every hospital will have access to a fully developed simulation laboratory and staff. The cost of establishing a simulation laboratory can range from greater than \$100,000 for a basic setup to millions for advanced centers (Hanberg, Brown, Hoadley, Smith, & Courtney, 2007; Lapkin & Levett-Jones, 2011). Similar results can be achieved with low-fidelity means, however. This would involve the instructor reading the scenario and writing patient data on a white board. There are a number of drawbacks to this method, chiefly a loss of realism. Additionally, with the computerized manikin and monitors, the simulator can display subtle changes in a patient's status without the instructor calling attention to the change. This would be impossible if the instructor was required to write everything on a white board.

Conclusion

The use of high-fidelity simulation training in the orientation of new graduate ICU nurses is a highly effective training tool if managed correctly. Creating scenarios is a time consuming task; however, this enables the tailoring of the scenario to the needs of the learner. The use of a guiding framework is essential to ensure maximal benefit.

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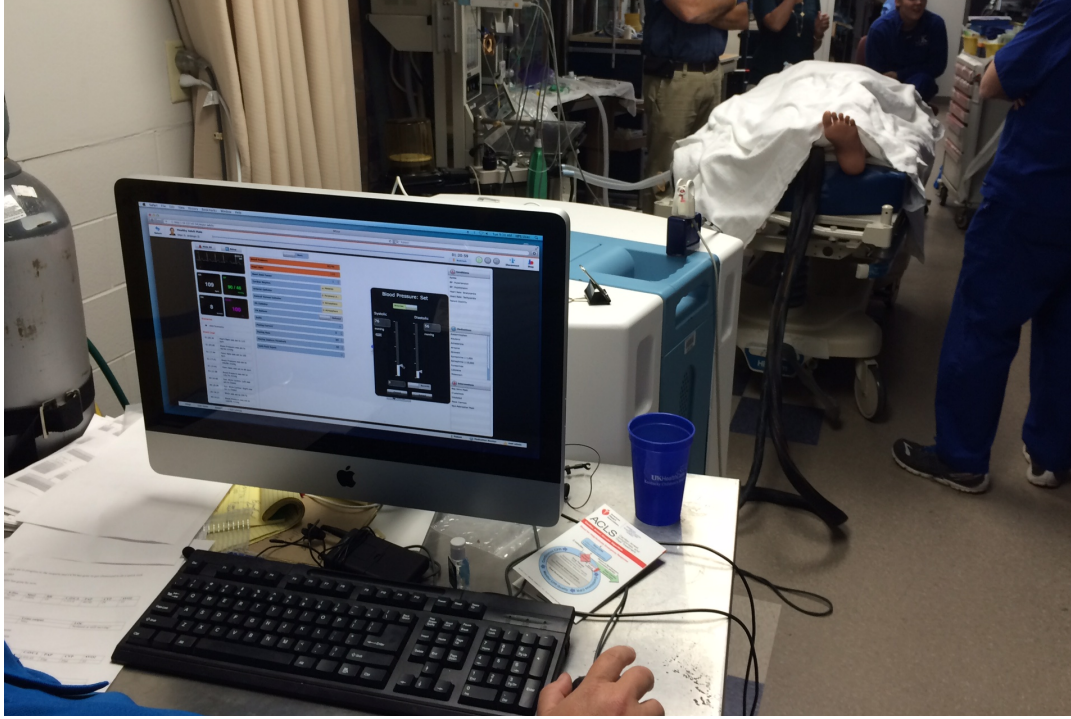


Figure 1. The simulation laboratory viewed from the simulator control desk.



Figure 2. Students working in the simulation laboratory

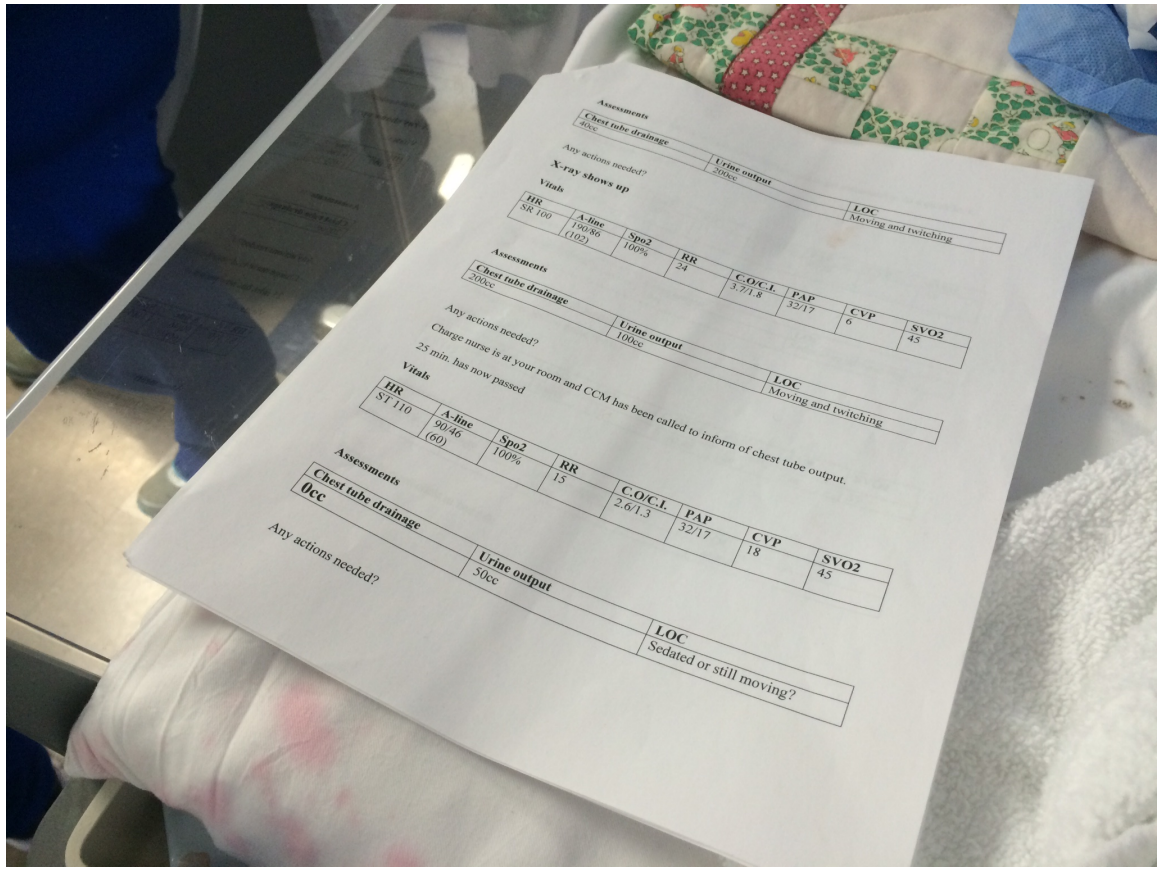


Figure 3. An example of one of the scenarios in the simulation laboratory

Evaluation of a High-Fidelity Simulation Training Program for
New Cardiothoracic ICU Nurses

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Abstract

Objectives: The objective of this pilot study was to evaluate the effect on learning and confidence of nurses following inclusion of a high-fidelity simulation training program as part of a new graduate nursing internship in the cardiothoracic ICU.

Background: New nurses, particularly those in critical care, experience high levels of stress related to adaptation to their new roles and integrating their education with clinical practice. They also demonstrate low levels of self-confidence in their ability to care for critically ill patients. The use of high-fidelity patient simulation training has been shown to improve learning and confidence among critical care nurses.

Materials and Methods: Nurse interns participated in a high-fidelity simulation class. Each nurse completed a simulation involving common post cardiac surgery complications followed by a group debriefing session. A 10-question multiple-choice knowledge test (MCKT) was used to assess knowledge. The Modified Self-Efficacy Scale (MSES), ranging from 10 to 40 with increasing value indicating greater confidence, was used to assess confidence. Both scales were administered pre and post course and again at a two-week follow-up. The Simulation Effectiveness Tool (SET), a 0 to 2 Likert scale with learning and confidence subscales, was used to evaluate participants' perceptions of the program. Higher scores indicate greater perceived effectiveness. Paired t-tests were conducted to compare pre and post course scores as well as post course and follow-up scores for both the MCKT and MSES. Spearman's rho was used to compare subjective assessment of learning (SET learning subscale) with objective assessment (MCKT)

and to compare improvement in learning (MCKT) with improvement in confidence (MSES).

Results: Ten of the 12 interns (75% female, mean age 27.67 SD=6.67 years) completed the course and two-week follow up testing. Following the simulation exercise, mean MCKT scores improved from 48.18% (SD=14.7) to 60.9% (SD=22.6; $p < 0.05$) and MSES scores improved from 20.8 (SD=5.17) to 25.9 (SD=3.3; $p < 0.05$). Both scales had insignificant changes at the two week follow-up testing. The overall mean SET score was 1.64 (SD=0.56) with a learning subscale score of 1.76 (SD=0.56) and confidence subscale score of 1.48 (SD=0.61). There was no correlation between the objective and subjective learning assessments as well as no correlation between the improvement in learning and improvement in confidence.

Conclusion: The inclusion of a high-fidelity simulation course showed improvement in both learning and confidence among the new graduate nurses with good retention at the two week follow up. As there appears to be no correlation between the subjective and objective learning assessments, an objective learning assessment tool is needed. It is also important to note that an improvement in confidence may not indicate an improvement in actual ability.

It is well documented in the literature that nursing experience is positively correlated with patient outcomes in the Intensive Care Unit (ICU; Morrison et al., 2001). However, with many experienced nurses retiring or taking positions away from the bedside and many younger nurses leaving to pursue advanced practice or management and leadership positions, maintaining high levels of experience among the ICU nursing staff is increasingly difficult (AMN Healthcare, 2013). Additionally, new graduate nurses experience high levels of stress related to adaptation to their new roles, integrating the knowledge they obtained in school with what they are learning during clinical orientation, and low levels of self-confidence in their ability to care for acutely and critically ill patients (Delaney, 2003). This stress may be a contributing factor for younger nurses leaving the bedside early due to burnout or to pursue opportunities in other areas that may afford more flexible schedules, less physically demanding work, or greater opportunity for career advancement (MacKusick & Minick, 2010).

The cardiothoracic intensive care unit (CTICU) poses unique orientation challenges for new graduate nurses. In addition to the high acuity normally found in other ICUs, nurses in the CTICU must be able to receive patients directly from the operating room while still under general anesthesia and care for them during the critical time period immediately following surgery. In addition to the multiple vasoactive infusions and mechanical ventilation frequently encountered in other ICUs, these patients typically have thoracic drains, pulmonary artery catheters, and external temporary pacemakers. The CTICU nurse also frequently needs to manage additional support devices such as intra-aortic balloon pumps (IABP), ventricular

assist devices (VAD), or extracorporeal membrane oxygenation (ECMO). This means that new nurses in this environment will have a large amount of knowledge to integrate and need to be able to function under stressful conditions and make decisions rapidly.

High-fidelity simulation has been used in other high-reliability fields such as aviation and nuclear power to train individuals and to improve their abilities. The use of simulation training has likewise been shown to improve both learning and confidence among healthcare providers (Abe et al., 2013; Kaddoura, 2010b; Kane et al., 2011).

The objective of this pilot study was to evaluate the effect on learning and confidence among new nurses using a high-fidelity simulation training program as part of a new graduate nursing internship in the CTICU. Internship programs are designed to help new graduate nurses make the transition from student to professional nurse (Herdrich & Lindsay, 2006). The CTICU has operated such a program since 2012. The internship program lasts six months and combines elements of the standard preceptorship model of training with lectures by experienced nurses and physicians. Simulation training, however, has never been included.

Methods

The nurse interns from the CTICU were used as a convenience sample. All participants took part in a four-hour high-fidelity simulation class covering basic post-operative care and potential complications following cardiac surgery. In order to facilitate learning and to accommodate the physical space available in the

simulation laboratory, the participants were randomly assigned to two smaller groups.

Each intern had completed 8-10 weeks of the six-month internship when they participated in the class. This time frame was chosen to allow each participant to gain some experience in the role of a professional nurse as differentiated from a nursing student and to gain some confidence in basic nursing abilities. However, at this point in the internship, none of the participants had progressed to the point of caring for patients in the immediate post-operative period.

Five simulation scenarios involving common post cardiac surgery complications were developed by a group of experienced CTICU nurses and physicians from the Department of Anesthesiology, Division of Critical Care Medicine (CCM), who provide intensivist coverage for the CTICU. Each intern completed a randomly selected scenario in the role of the primary nurse, while the remainder of the group observed. As these scenarios were designed to be instructional rather than as an evaluation of participant knowledge and ability, participants were allowed to “pause” the scenario and ask questions of either the instructor or their fellow interns. Following each scenario, the instructor led a group debriefing session.

Instruments

In order to evaluate the impact of the simulation class on participant learning and confidence, three instruments were used. To assess learning/knowledge, a multiple choice knowledge test (MCKT) was developed by the authors and validated

by an independent group of experienced CTICU nurses and CCM physicians. The MCKT consisted of 10 questions covering typical postoperative complications.

To assess the impact on participant confidence, a modified self-efficacy scale (MSES) was used. This instrument is a modification of a general self-efficacy scale proposed by Schwarzer and Jerusalem (1995). The MSES is a 10-item questionnaire with scores ranging from 10-40; higher scores indicate greater levels of self-confidence. Consistent with its use in prior studies, the questions were modified to specifically address the tasks evaluated in this study, the care of the patient immediately following cardiac surgery.

Finally, the Simulation Effectiveness Tool (SET) was used to evaluate the participant's perceptions of the overall effectiveness of the simulation class (Elfrink Cordi et al., 2012). The SET is a validated 13-item questionnaire using a 0-2 Likert scale with higher scores indicating greater perceived effectiveness. Of particular interest to this study, the SET has both learning and confidence subscales, allowing us to gain a subjective assessment of learning and confidence with which to compare to the objective assessments provided by the MCKT and MSES.

Both the MCKT and MSES were completed immediately before and after the simulation class. In order to assess the retention of any effects of the class, all study participants completed both of these instruments again two weeks later. The SET was completed immediately after the simulation course.

Statistical Analysis

Paired t-tests were conducted to compare pre and post course scores as well as post course and follow-up scores for both the MCKT and MSES. Spearman's rho

was used to correlate subjective assessment of learning (SET learning subscale) with objective assessment (MCKT) and to correlate improvement in learning (changes in MCKT scores from pre to post intervention) with improvement in confidence (changes in MSES scores from pre to post intervention). Subgroup analysis of all results was conducted to determine if there was significant variability in the results by demographic factors (e.g. gender, ethnicity, education, professional background). All statistical analysis was conducted using SPSS (IBM Corp., Armonk, NY).

Results

Initially, 13 CTICU nurse interns were recruited for participation; however, one withdrew just prior to the simulation class, leaving 12 to complete the study (see Table 1). The group was predominately composed of white females with a mean age of 27.67 years (SD=6.67). The majority had Bachelor of Science in Nursing degrees, and although none had prior nursing experience, most had prior exposure to the ICU as either unlicensed assistive personnel (certified nursing assistants, nursing care technicians) or through some kind of extended clinical experience over and above what was expected of the general nursing student (e.g. a summer internship). There was insufficient variability to allow for subgroup analysis by any factor other than gender.

Following the simulation class, mean MCKT scores (Figure 1) improved from 48.18% (SD=14.7) to 60.9% (SD=22.6; $p < 0.05$) and MSES scores (Figure 2) improved from 20.8 (SD=5.17) to 25.9 (SD=3.3; $p < 0.05$). Both scales had insignificant changes at the two-week follow-up testing. The overall mean SET score

(Figure 3) was 1.64 (SD=0.56) with a learning subscale score of 1.76 (SD=0.56) and a confidence subscale score of 1.48 (SD=0.61). There was no correlation between the objective and subjective learning assessments (Spearman's rho = -0.388; Figure 4). Additionally, no correlation was shown between the improvement in learning and improvement in confidence (Spearman's rho = 0.116; Figure 5).

Discussion

Improving knowledge and confidence are two of the major goals of the orientation training of new nurses. While new graduate nursing internships have begun to be implemented in order to help achieve these goals, innovative training methods such as simulation may hold even greater promise. Previous authors have found that simulation training may be superior to more traditional teaching methodologies such as reading assignments or lectures (Lewis et al., 2012; Schroedl et al., 2012). In fact, some evidence suggests that simulation training is even more effective than actual clinical experience (Singer et al., 2013). The benefits of simulation training also seem to be greatest in novice learners (Musacchio et al., 2010; Pascual et al., 2011; Plante, 2006).

This pilot project was able to demonstrate that the use of high-fidelity simulation training can improve both learning and confidence among new graduate nurses. Not only were statistically significant improvements noted following the simulation class, but also these improvements remained at the two week follow up testing. The fact that scores did not return to baseline two weeks later is particularly important as it demonstrates the ability of simulation training to effect lasting change.

Although the overall mean SET learning subscale score indicates that the participants felt relatively strongly that the simulation class improved their knowledge of the subject matter, when individual SET scores were correlated with the individual MCKT scores, no relationship was demonstrated. An important point is that an individual's perception of his or her own knowledge is not necessarily a reliable indicator of improvement. This underscores the importance of objective testing of new nurses during the training process, rather than reliance on subjective impressions.

It is also important to note that an improvement in confidence may not indicate an improvement in actual ability. In this study, although both confidence and knowledge improved following the simulation class, no correlation between the two could be demonstrated. This is consistent with previous studies of simulation in healthcare workers and again emphasizes the need for objective assessment of knowledge and ability (Mould et al., 2011; Tofil et al., 2011b)

The small sample size, use of a convenience sample, and this study being limited to a single institution are obvious limitations that prevent generalizability of the results. Another limitation is the short time allowed for follow up. It is debatable whether two weeks is enough time to evaluate the long-term impact of the simulation training; however, as the amount of time following the simulation increases, the clinical experience of the individual participant also increases and may confound the results of further testing. However, despite these limitations, statistical significance was achieved and the overall results were consistent with what has been previously reported in the literature in other populations.

Given the results of this study in combination with the previous work done on the effectiveness of simulation training, simulation training has the potential to result in better nursing care and improved patient outcomes. This type of training, when incorporated into a new graduate nursing internship program, may also result in greater long-term benefits, such as improved retention. Further study is needed to examine these hypotheses.

Conclusion

The inclusion of a high-fidelity simulation class as part of a new graduate nurse internship program in the CTICU showed improvement in both learning and confidence among the new nurses. As there seems to be no correlation between the subjective and objective learning assessments, objective assessment is needed to ensure competency. It is also important to note that an improvement in confidence may not indicate an improvement in actual ability. Further study is needed to determine the long-term impact of simulation training on factors such as patient outcomes and nurse retention.

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Table 1.

Demographic Characteristics of Study Participants

	N(%)
Gender	
Male	3(25)
Female	9(75)
Ethnicity	
White	10(83.3)
Black	1(8.3)
Asian	1(8.3)
Educational Background	
Bachelor of Science in Nursing (BSN)	11(91.7)
Associate Degree in Nursing (ADN)	1(8.3)
Prior exposure to ICU?	
Yes	10(83.3)
No	2(16.7)

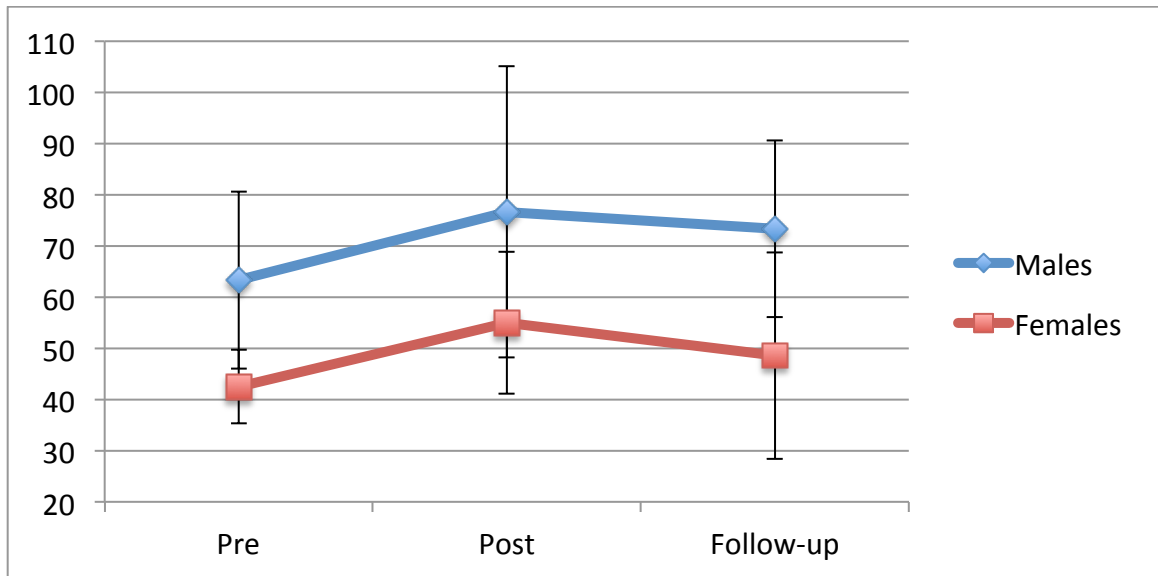


Figure 1. MCKT scores.

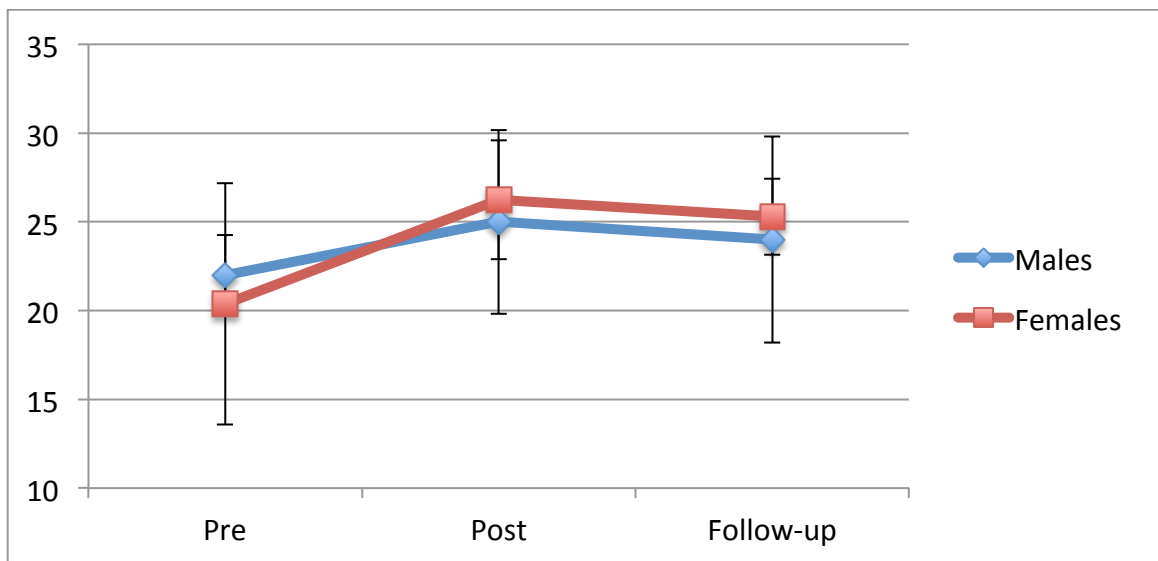


Figure 2. MSEs scores.

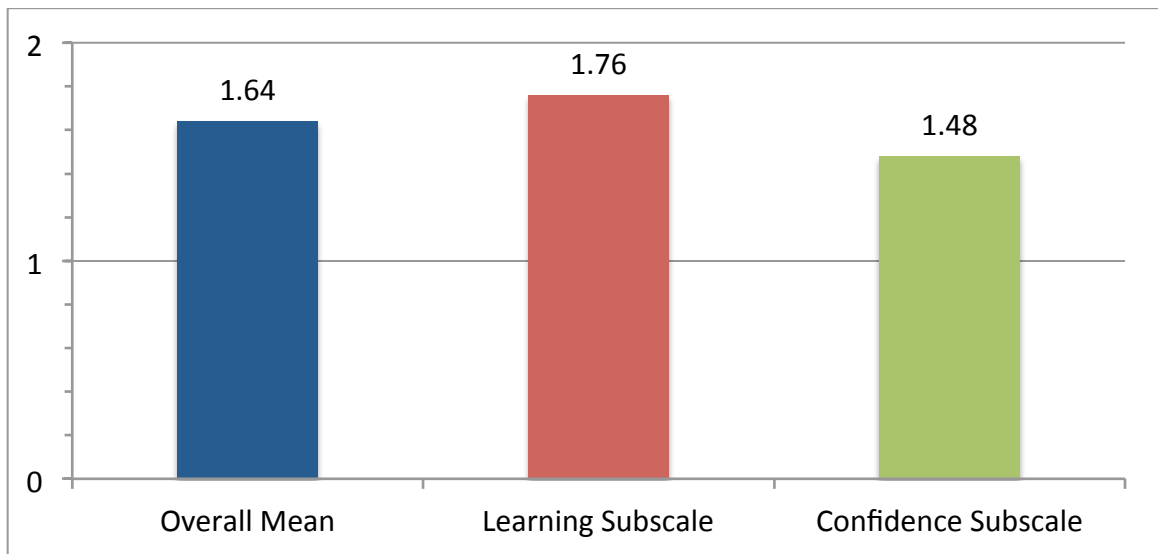


Figure 3. SET results.

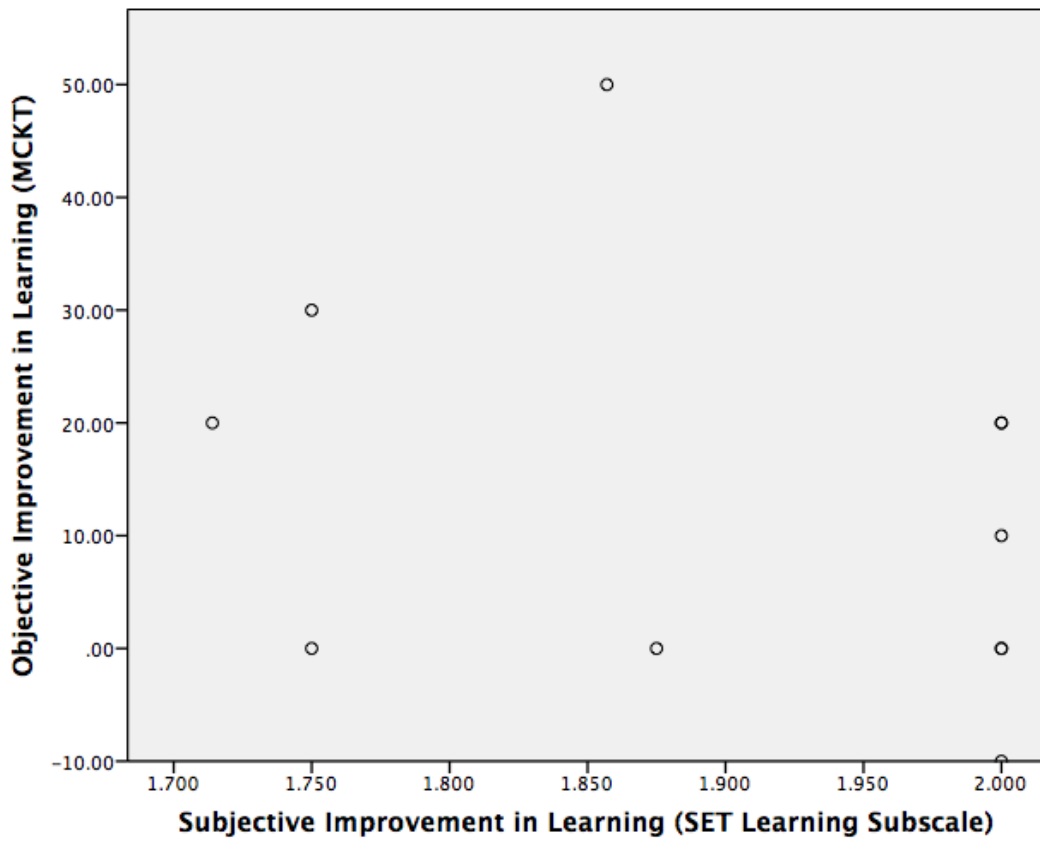


Figure 4. Correlation between subjective and objective learning assessment.

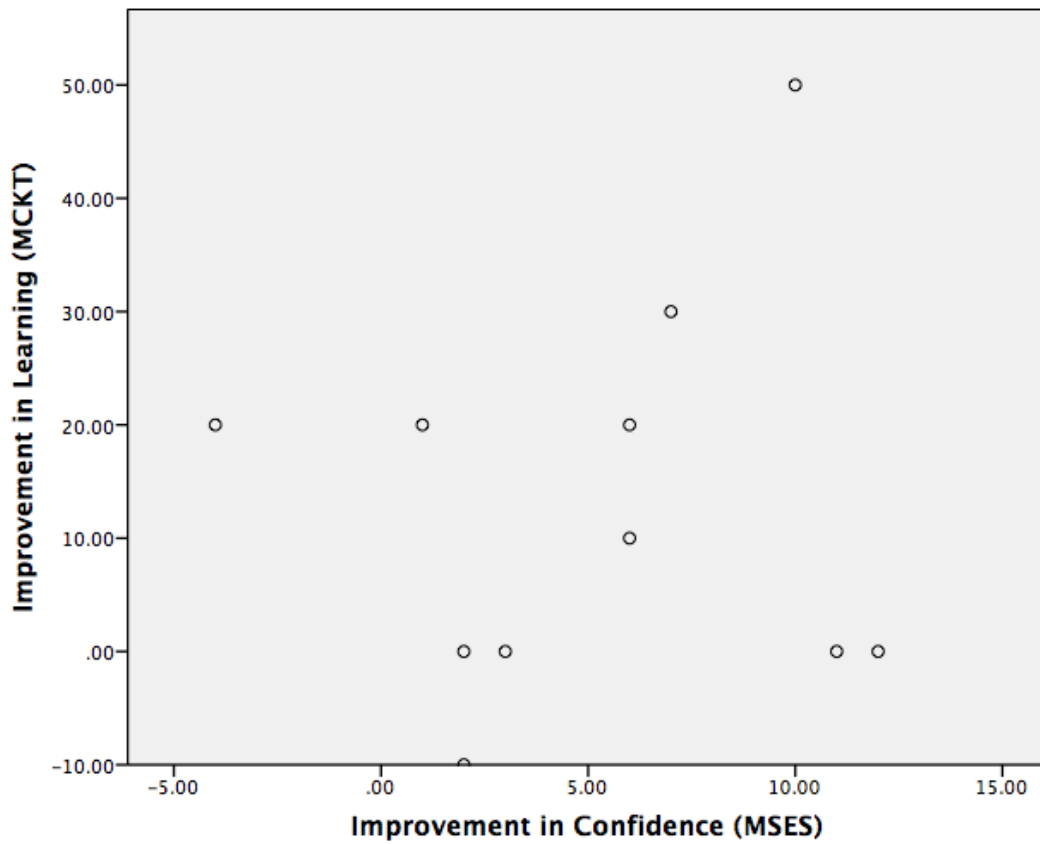


Figure 5. Correlation between objective and subjective confidence assessment.

DNP Final Project Report Conclusions

While nursing experience has been demonstrated to be a positive factor in patient outcomes, it is difficult to maintain experienced CTICU nursing staff. It is therefore essential that new and innovative training methods be identified that can help overcome deficiencies in experience. By maximizing exposure to unique situations and by customizing the clinical training, high-fidelity simulation provides better training than other modalities such as lecture or readings and may be even better than actual patient care experience. Additionally, this DNP final project has shown that inclusion of a high-fidelity simulation class as part of a new graduate internship program in the CTICU is able to improve both learning and confidence among new nurses.

The development of a simulation course is not without cost. Creating custom scenarios, while time and labor intensive, enables the tailoring of the scenario to meet the needs of the learner. The financial cost of equipment is also not insignificant. Although there are ways to reduce these costs by using “low-tech” substitutions, a sacrifice in realism must be made.

Important caveats exist and need to be considered. Because of the lack of demonstrable correlation between objective and subjective assessments of learning, objective assessment must be included in the training program to ensure competency. It is also important to note that an improvement in confidence may not indicate an improvement in actual ability.

The long-term effects of simulation training on patient outcomes and nurse retention and satisfaction are not known and further study is needed in these areas.

Additionally, it is unclear what the cost/benefit ratio is given the high costs associated with simulation training. However, despite the expense and time involved, I believe that simulation training is beneficial and should be included as part of a new graduate internship training program in the CTICU.

Appendix A: Multiple Choice Knowledge Test (MCKT)

- 1) Your patient is a 65 year old male who is 2 hours status post CABG x3. He remains intubated and sedated. His heart rate is 105 bpm, MAP 45, CO/CI 4.5/2.0, CVP 5. Upon arrival to the ICU, there was 20ml of urine in the Foley bag, but he has only made 30 ml over the past 2 hours. Chest tube output has been 10-20mls/hour since the end of surgery. Initial labs reveal Hct 24.1, K+ 4.0. Which of the following would you expect to do first?
 - a. Give 250ml of albumin
 - b. Start norepinephrine at 0.02 mcg/kg/min
 - c. Give 1 unit PRBCs
 - d. Start Dobutamine at 2.5 mcg/kg/min
- 2) You're taking care of a 71 year old female who arrived in the ICU 3 hours ago status post AVR & Maze Procedure. She remains intubated and sedated. Her heart rate is 128, MAP 50, CO/CI 3.5/1.9, CVP 1. Chest tube output over the past 3 hours has been 100ml, 80ml, 90ml. Urine output has been 25-35 ml/hr over the past three hours. Initial labs reveal Hct 20.2, K+ 3.9. Which of the following would you expect to do first?
 - a. Give 250ml of albumin
 - b. Start Dopamine at 2 mcg/kg/min
 - c. Give 1 unit PRBCs
 - d. Start norepinephrine at 0.02 mcg/kg/min
- 3) Your patient is a 56 year old male who underwent an emergent CABG x2 an hour ago. He remains intubated and sedated in the ICU. His heart rate is 100, MAP 51, CO/CI 2.5/1.2, CVP 6, PA 35/21. Initial labs reveal Hct 22.3, K+3.8. Urine output has averaged 35 ml/hour. Chest tube output has averaged 40ml/hr since arrival. Which of the following would you expect to do first?
 - a. Give 250ml of albumin
 - b. Start Dopamine at 2 mcg/kg/min
 - c. Give 1 unit of PRBCs
 - d. Start epinephrine at 0.02 mcg/kg/min
- 4) Your patient is a 69 year old male who is 3 hours status post CABG x4. He remains intubated and sedated. His heart rate is 126 bpm, MAP 48, CO/CI 5/2.3, CVP 5. Since arrival to the ICU, he has averaged 30ml of urine per hour. Chest tube output has been 10-20mls/hour since the end of surgery. Initial labs reveal Hct 24.1, K+ 4.0. Which of the following would you expect to do first?
 - a. Give 250ml of albumin
 - b. Start norepinephrine at 0.02 mcg/kg/min
 - c. Give 1 unit PRBCs

- d. Start Dobutamine at 2.5 mcg/kg/min
- 5) You're taking care of a 61 year old female who arrived in the ICU 2 hours ago status post CABG x3. She remains intubated and sedated. Her heart rate is 122, MAP 50, CO/CI 3.5/1.9, CVP 1. Chest tube output over the past 3 hours has been 30ml, 20ml, 40ml. Urine output has been 25-35 ml/hr over the past three hours. Initial labs reveal Hct 26.2, K+ 3.9. Which of the following would you expect to do first?
- Give 250ml of albumin
 - Start Dopamine at 2 mcg/kg/min
 - Give 1 unit PRBCs
 - Start norepinephrine at 0.02 mcg/kg/min
- 6) Your patient is a 69 year old male who is 3 hours status post CABG x5. He remains intubated and sedated. His heart rate is 124 bpm, MAP 47, CO/CI 4.4/1.9, CVP 6. Upon arrival to the ICU, there was 35ml of urine in the Foley bag, but he has only made 40 ml over the past 3 hours. Chest tube output has been 10-20mls/hour since the end of surgery. Initial labs reveal Hct 25.2, K+ 4.1. Which of the following would you expect to do first?
- Give 250ml of albumin
 - Start norepinephrine at 0.02 mcg/kg/min
 - Give 1 unit PRBCs
 - Start Dobutamine at 2.5 mcg/kg/min
- 7) Your patient is a 56 year old male who underwent an MVR an hour ago. He remains intubated and sedated in the ICU. His heart rate is 105, MAP 50, CO/CI 2.5/1.2, CVP 6, PA 35/21. Initial labs reveal Hct 24.3, K+3.8. Urine output has averaged 35 ml/hour. Chest tube output has averaged 40ml/hr since arrival. Which of the following would you expect to do first?
- Give 250ml of albumin
 - Start Dopamine at 2 mcg/kg/min
 - Give 1 unit of PRBCs
 - Start epinephrine at 0.02 mcg/kg/min
- 8) You're taking care of a 65 year old female who arrived in the ICU 3 hours ago status post CABG x2. She remains intubated and sedated. Her heart rate is 130, MAP 52, CO/CI 3.7/1.9, CVP 1. Chest tube output over the past 3 hours has been 150ml, 180ml, 140ml. Urine output has been 25-35 ml/hr over the past three hours. Initial labs reveal Hct 19.5, K+ 3.7. Which of the following would you expect to do first?
- Give 250ml of albumin
 - Start Dopamine at 2 mcg/kg/min
 - Give 1 unit PRBCs
 - Start norepinephrine at 0.02 mcg/kg/min

- 9) Your patient is a 59 year old male who is 3 hours status post AVR & MVR. He remains intubated and sedated. His heart rate is 122 bpm, MAP 50, CO/CI 5.1/2.5, CVP 8. Since arrival to the ICU, he has averaged 30ml of urine per hour. Chest tube output has been 10-20mls/hour since the end of surgery. Initial labs reveal Hct 24.1, K+ 4.0. Which of the following would you expect to do first?
- Give 250ml of albumin
 - Start norepinephrine at 0.02 mcg/kg/min
 - Give 1 unit PRBCs
 - Start Dobutamine at 2.5 mcg/kg/min
- 10) You're taking care of a 55 year old female who arrived in the ICU 2.5 hours ago status post AVR. She remains intubated and sedated. Her heart rate is 125, MAP 52, CO/CI 3.5/1.9, CVP 1. Chest tube output over the past 3 hours has been 30ml, 20ml, 40ml. Urine output has been 25-35 ml/hr over the past three hours. Initial labs reveal Hct 25.5, K+ 3.8. Which of the following would you expect to do first?
- Give 250ml of albumin
 - Start Dopamine at 2 mcg/kg/min
 - Give 1 unit PRBCs
 - Start norepinephrine at 0.02 mcg/kg/min

CABG-Coronary Artery Bypass Graft
MAP-Mean Arterial Pressure
BPM-beats per minute
CO/CI-Cardiac Output/Cardiac Index
CVP-Central Venous Pressure
Hct-Hematocrit
AVR-Aortic Valve Replacement
MVR-Mitral Valve Replacement
K+-Potassium
PA-Pulmonary Artery Pressure

Answers

- 1) B
- 2) C
- 3) D
- 4) B
- 5) A
- 6) B
- 7) D
- 8) C

- 9) B
10) A

Appendix B: Modified Self Efficacy Scale (MSES)

Directions: Please indicate your agreement or disagreement with the statement using the following scale by circling the appropriate number:

1= Not at all true 2= Hardly true 3= Moderately true 4= Exactly true

1) I can always select the proper treatment (vasopressor, inotrope, volume resuscitation) for low blood pressure/low cardiac output in the post-cardiac surgery patient.

1 2 3 4

2) I can gather and organize supplies necessary treating low blood pressure/low cardiac output in the post-cardiac surgery patient.

1 2 3 4

3) I can focus on the patient and select the proper treatment (vasopressor, inotrope, volume resuscitation) for low blood pressure/low cardiac output.

1 2 3 4

4) I can deal effectively with unexpected events while treating low blood pressure/low cardiac output in the post-cardiac surgery patient.

1 2 3 4

5) I can handle unforeseen situations while treating low blood pressure/low cardiac output in the post-cardiac surgery patient.

1 2 3 4

6) I can solve most low blood pressure/low cardiac output problems in the post-cardiac surgery patient.

1 2 3 4

7) I can remain calm when facing difficulties while treating low blood pressure/low cardiac output in the post-cardiac surgery patient.

1 2 3 4

8) When I am confronted with a problem when treating low blood pressure/low cardiac output in the post-cardiac surgery patient, I can think of several solutions.

1 2 3 4

9) If I am in trouble, treating low blood pressure/low cardiac output in the post-cardiac surgery patient, I can solve the problem.

1 2 3 4

10) I can handle whatever happens when I treating low blood pressure/low cardiac output in the post-cardiac surgery patient.

1 2 3 4

This scale was modified from the General Self-Efficacy (GSE) scale:

Schwarzer, R., & Jerusalem, M. (1995). Generalized Self-Efficacy scale. In J. Weinman,

S. Wright, & M. Johnston, Measures in health psychology: A user's portfolio.

Causal and control beliefs (pp. 35-37). Windsor, UK: NFER-NELSON

Appendix C: Simulation Effectiveness Tool



PNCI® Simulation Effectiveness Tool

Date: _____

Course: _____

Instructor: _____

Name (Optional): _____

Please rate the following statements on the scale provided. Mark NA if you have no experience with the statement.

	Do Not Agree	Somewhat Agree	Strongly Agree	Not Applicable
The instructor's questions helped me to think critically	0	1	2	NA
I feel better prepared to care for real patients	0	1	2	NA
I developed a better understanding of the pathophysiology of the conditions in the SCE	0	1	2	NA
I developed a better understanding of the medications that were in the SCE	0	1	2	NA
I feel more confident in my decision-making skills	0	1	2	NA
I am more confident in determining what to tell the healthcare provider	0	1	2	NA
My assessment skills improved	0	1	2	NA
I feel more confident that I will be able to recognize changes in my real patient's condition	0	1	2	NA
I am able to better predict what changes may occur with my real patients	0	1	2	NA
Completing the SCE helped me understand classroom information better	0	1	2	NA
I was challenged in my thinking and decision-making skills	0	1	2	NA
I learned as much from observing my peers as I did when I was actively involved in caring for the simulated patient	0	1	2	NA
Debriefing and group discussion were valuable	0	1	2	NA

Comments: _____

Appendix D: Simulation Scenarios

Scenario 1

Goal: To manage a patient in the immediate post-operative period with heart failure and need for transfusion

Objectives:

1. Assess a post-operative patient
2. Calculate SVR
3. Identify need for inotropes
4. Identify need for blood transfusion

Vitals are displayed on monitor. No other data beyond introduction are given to student unless specifically marked. Students may assume they have orders for any intervention they wish to try.

Introduction: Mr. John Brooks is a 56 year old male who presented to the Emergency Department earlier this evening c/o 9/10 substernal chest pain radiating to his neck. The pain was partially relieved with sublingual nitroglycerin. ECG revealed ST elevation in leads II, III, and aVF. He was taken emergently to the cath lab where he was found to have a 100% RCA lesion and a 75% LAD lesion. The cath lab team was unable to stent either of the lesions and so Mr. Brooks was taken emergently to the OR for CABG.

He arrives to the ICU in stable condition, sedated with 10 mg/kg/min of propofol. He is on 1 unit/hour of IV insulin and 0.2mcg/kg/min of nitroglycerin. He is intubated with a 7.5 ETT (23mm at the lip). Vent settings are PRVC, rate of 15, $V_T=500$, $FiO_2=60\%$, PEEP of 5. He has 2 mediastinal chest tubes to 1 atrium and a JP

drain in the right chest. He has a right radial arterial line, a right IJ Mac with a SWAN at 42 cm, and a 16g PIV in the left hand.

The chest tube has drained 40ml of blood. There is 40ml of dark yellow urine in the Foley catheter.

Stage 1

Vitals:

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP
NSR @ 95bpm	90/55 (67)	99%	15	30	4.8/2.4	18/12 (14)	3

Assessment:

Sedated, EMV 3T, PERRLA @2, Lungs CTAB, S₁S₂ w/o m/r/g, +2 pulses x4, absent bowel sounds, +1 generalized edema

1	Assess patient
2	Recognize normal post-operative assessment

Stage 2

2 hours later

Vitals:

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 100bpm	75/49(58)	95%	15	31	2.5/1.25	28/20(23)	6	55

Chest tube output since arrival: 80ml, UOP since arrival: 70ml

Assessment:

Sedated, EMV 3T, PERRLA @2, Lungs crackly, S₁S₂S₃ w/o m/r/g, +1 pulses x4, absent bowel sounds, +1 generalized edema

Labs: (Routine, given to student without asking)

Hct: 22.3

K+: 3.8

3	Reassess patient
4	Identify lung crackles
5	Identify diminished pulses from previous assessment
6	Assess chest tube output
7	Assess urine output
8	Identify inadequate urine output

9	Identify low K+
10	Replace K+
11	Calculate SVR
12	Identify heart failure
13	Select inotrope administration

Solution:

SVR: ((MAP - CVP) x 79.9)/CO = 1660

Heart failure, the patient needs inotrope

***if inotrope is started

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 115bpm	88/52(64)	95%	15	31	4.3/2.15	22/19(20)	4	62

***if volume is given

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 120bpm	70/33(45)	90%	15	31	2.0/1.0	43/28(33)	10	50

***if vasopressors are started

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 120bpm	70/33(45)	95%	15	31	2.0/1.0	43/28(33)	10	38

Stage 3

1 hour later

UOP 10ml/hr (given to student)

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 100bpm	75/49(58)	90%	15	31	2.2/1.1	35/22(26)	10	44

14	Identify low urine output
15	Calculate SVR
16	Select volume administration

Solution

SVR 1750

Options:

Volume

Bladder Scan

Vasopressors

***volume

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 100bpm	75/49(58)	90%	15	31	2.2/1.1	35/22(26)	10	35

Stage 4

1 hour later UOP 5 (Given to student)

17	Identify low urine output
18	Check Hct
19	Identify vasopressors needed while waiting on Hct

Options:

Inotropes

Vasopressors

Check Hct

***if vasopressors

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 100bpm	88/54(65)	90%	15	31	2.0/1.0	43/28(33)	10	40

Hct - 17

20	Identify low Hct
21	Transfuse blood

***if blood

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 90bpm	88/54(65)	90%	15	31	3.5/1.75	43/28(33)	10	58

***if inotrope

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 120bpm	75/46(56)	90%	15	31	2.7/1.35	30/20(23)	10	35

Scenario 2

Goal: To manage a hypovolemic patient in the immediate post-operative period

Objectives:

5. Assess a post-operative patient
6. Calculate SVR
7. Identify need for volume administration
8. Identify need for blood transfusion

Vitals are displayed on monitor. No other data beyond introduction are given to student unless specifically marked. Students may assume they have orders for any intervention they wish to try.

Introduction: Susan Grey is a 63-year-old female who just underwent an AVR with mechanical valve for aortic insufficiency. Her PMH is significant for CAD with a stent to the RCA in 2005, HTN, HLD, DM2, and COPD. She is a former 2-ppd smoker who quit 5 years ago.

She arrives to the ICU in stable condition, sedated with 25 mg/kg/min of propofol. She is on 2.5 units/hour of IV insulin and 0.02mcg/kg/min of norepinephrine. Anesthesia reports that she was stable throughout the case. She is intubated with a 7.0 ETT (23mm at the lip). Vent settings are PRVC, rate of 15, $V_T=500$, $FiO_2=60\%$, PEEP of 5. He has 1 mediastinal chest tube to 20cm H₂O suction. She has a right radial arterial line, a right IJ Mac with a SWAN at 42 cm, and a 16g PIV in the left hand. She has V-pacing wires; current settings are VVI @ 60, 10 mA, 2 mV.

The chest tube has drained 40ml of blood. There is 40ml of dark yellow urine in the Foley catheter. Her intraoperative I/Os are as follows:

- Crystalloid 1000ml
- PRBC 1 unit
- Urine output 1500ml

Stage 1

Vitals:

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
NSR @ 100bpm	90/50 (63)	99%	15	30	4.0/2.5	63	18/12 (14)	4	35.8

Assessment:

Sedated, EMV 3T, PERRLA @2, Lungs CTAB, S₁S₂ w/o m/r/g, +2 pulses x4, absent bowel sounds, +1 generalized edema

Initial Orders (given to student)

- Albumin 250ml x4
- Nitroglycerin (NTG) gtt to keep MAP < 90
- Norepinephrine (NE) gtt to keep MAP > 60
- Transfuse 1 unit PRBC for Hct < 21

1	Assess patient
2	Recognize low temperature
3	Apply Bair Hugger/Warm blankets

Stage 2

30 mins later

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
ST @ 105bpm	87/44(58)	95%	15	31	3.9/2.4	61	17/11(13)	3	36

Chest tube output since arrival: 80ml, UOP since arrival: 45ml

4	Assess chest tube output
5	Recognize normal chest tube output
6	Assess urine output
7	Recognize normal urine output
8	Titrate down propofol

Response

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
ST @ 105bpm	90/49(63)	95%	15	31	3.9/2.4	61	17/11(13)	3	36

Stage 3

1 hr after ICU arrival

Vitals:

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
ST @ 118bpm	85/40(55)	95%	15	31	3.0/1.9	59	16/10(12)	2	36

Chest tube output since arrival: 180ml, UOP since arrival: 50ml

Labs (routine, given to student):

- Hct 22.1
- K+ 3.9

9	Assess chest tube output
10	Recognize normal chest tube output
11	Assess urine output
12	Recognize low K+
13	Replace K+
14	Recognize low urine output
15	Calculate SVR (1412)
16	Administer 250ml Albumin

***if albumin is given

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
ST @ 110bpm	88/52(64)	95%	15	31	3.4/2.1	62	17/11(13)	4	36.4

***if NE is increased

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
ST @ 110bpm	86/45(59)	95%	15	31	2.8/1.7	57	17/11(13)	4	36.4

Stage 4

2 hours later (in ICU for 3 hours)

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
ST @ 128bpm	73/40(51)	91%	15	31	2.9/1.8	52	17/11(13)	2	36.7

Chest tube output since arrival: 390ml, UOP since arrival: 100ml

17	Assess chest tube output
18	Recognize normal chest tube output
19	Assess urine output
20	Recognize low urine output
21	Calculate SVR $((MAP - CVP) \times 79.9) / CO = 1350$
22	Administer 250ml Albumin
23	Check Hct

***if albumin is given

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
ST @ 120bpm	84/44(57)	91%	15	31	3.0/1.9	46	17/11(13)	7	36.4

***if NE is increased

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	SvO ₂	PA	CVP	Temp
ST @ 126bpm	86/45(59)	91%	15	31	2.6/1.6	49	28/16(20)	4	36.4

Hct - 19.8

24	Recognize low Hct								
25	Transfuse 1 unit PRBC								
ST @ 110bpm	86/50(62)	95%	15	31	3.5/2.2	64	17/11(13)	9	36.4

Scenario 3

Goal: To manage a patient in the immediate post-operative period with cardiac tamponade

Objectives:

1. Assess a post-operative patient
2. Identify signs and symptoms of cardiac tamponade
3. Identify need to call surgeon emergently

Vitals are displayed on monitor. No other data beyond introduction are given to student unless specifically marked.

Introduction: Mr. David Johnson is a 67 year old male who arrives in the ICU following an elective CABG x4. He arrives to the ICU in stable condition, sedated with 0.5 mcg/kg/min of precedex. He is on 1 unit/hour of IV insulin and 0.25 mcg/kg/min of milrinone. He is intubated with a 7.5 ETT (23mm at the lip). Vent settings are PRVC, rate of 15, $V_T=450$, $FiO_2=60\%$, PEEP of 5. He has 2 mediastinal chest tubes to 1 atrium and a JP drain in the right chest. He has a right radial arterial line, a right IJ Mac with a SWAN at 42 cm, and a 16g PIV in the left hand.

The chest tube has drained 100ml of blood. There is 40ml of dark yellow urine in the Foley catheter.

Stage 1

Vitals:

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
NSR @ 83bpm	100/55 (70)	99%	15	30	4.8/2.4	18/12 (14)	3	68

Assessment:

Sedated, EMV 3T, PERRLA @2, Lungs CTAB, S₁S₂ w/o m/r/g, +2 pulses x4, absent bowel sounds, +1 generalized edema

1	Assess patient
2	Recognize normal post-operative assessment

Stage 2
1 hour later

Vitals:

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 98bpm	90/45(60)	95%	15	31	3.7/1.85	28/20(23)	6	55

Chest tube output since arrival: 20ml, UOP since arrival: 30ml

Assessment:

Sedated, EMV 3T, PERRLA @2, Lungs clear, S₁S₂ w/o m/r/g, +1 pulses x4, absent bowel sounds, +1 generalized edema

Labs (routine, given to student):

Hct: 22.3

K+: 3.8

3	Reassess patient
4	Identify clear lung sounds
5	Identify diminished pulses from previous assessment
6	Assess chest tube output
7	Assess urine output
8	Identify inadequate urine output
9	Identify low K+
10	Replace K+
11	Identify low SvO ₂
12	Calculate SVR $((MAP - CVP) \times 79.9) / CO = 1166$
13	Select volume or NE (both will have poor outcome)

***if volume is given

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 108bpm	90/53(65)	90%	15	31	2.6/1.3	30/26(27)	14	48

***if vasopressors are started

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 108bpm	95/55(68)	95%	15	31	2.0/1.0	32/28(29)	10	45

Stage 3

20 mins later

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 116bpm	75/60(65)	90%	22	25	1.4/1.2	40/32(35)	22	30

Assessment:

Massive JVD, muffled heart sounds, electrical alternans, pulsus paradoxus

14	Assess patient
15	Recognize JVD
16	Recognize muffled heart sounds
17	Recognize electrical alternans
18	Recognize pulsus paradoxus
19	Diagnose cardiac tamponade - CALL MD

Options

Volume

Recognize tamponade - **CALL MD**

***if volume

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 116bpm	60/50(53)	90%	15	18	0.9/0.45	40/32(35)	25	??

Scenario 4

Goal: To manage a patient in the immediate post-operative period with protamine reaction

Objectives:

1. Assess a post-operative patient
2. Calculate SVR
3. Identify need for vasopressors
4. Diagnose protamine reaction

Vitals are displayed on monitor. No other data beyond introduction are given to student unless specifically marked. Students may assume they have orders for any intervention they wish to try.

Introduction: Mr. John Smith is a 25 year old male who arrived in the ED 2 days ago with new onset AMS, fever, and was found to have vegetation on his TV. He just arrived in the ICU following an elective TVR for endocarditis. Surgery was approximately 9 hours, on-pump for 6.

He arrives to the ICU in stable condition, sedated with 150 mcg/hr of fentanyl. He is on 1 unit/hour of IV insulin. He is intubated with a 7.5 ETT (23mm at the lip). Vent settings are PRVC, rate of 15, $V_T=450$, $FiO_2=60\%$, PEEP of 5. He has 2 mediastinal chest tubes to 1 atrium and a JP drain in the right chest. He has a right radial arterial line, a right IJ Mac with a SWAN at 42 cm, and a 16g PIV in the left hand.

The chest tube has drained 100ml of blood. There is 40ml of dark yellow urine in the Foley catheter.

Stage 1

Vitals:

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
NSR @ 106bpm	90/44 (59)	99%	15	30	7.0/3.5	18/12 (14)	3	55

Assessment:

Sedated, EMV 3T, PERRLA @2, Lungs CTAB, S₁S₂ w/o m/r/g, +2 pulses x4, absent bowel sounds, +1 generalized edema

1	Assess patient
2	Recognize low MAP
3	Recognize low SvO ₂
4	Monitor for now

Stage 2

1 hour later

Vitals:

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 110bpm	70/37(48)	95%	15	31	7.0/3.5	18/12(14)	6	40

Chest tube output since arrival: 20ml, UOP since arrival: 10ml

Assessment:

Sedated, EMV 3T, PERRLA @2, Lungs clear, S₁S₂ w/o m/r/g, +1 pulses x4, absent bowel sounds, +1 generalized edema

Labs (routine, given to student):

Hct: 25.3

K+: 3.8

3	Reassess patient
4	Identify diminished pulses from previous assessment
5	Recognize low MAP
6	Recognize low SvO ₂
7	Assess chest tube output
8	Assess urine output
9	Identify inadequate urine output
10	Recognize low K+
11	Replace K+
12	Calculate SVR $((MAP - CVP) \times 79.9) / CO = 479$
13	Select pressors

***if volume is given

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 100bpm	75/42(53)	95%	15	31	6.7/3.35	18/13(15)	6	42

***if vasopressors are started

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 89bpm	95/50(65)	95%	15	31	4.4/2.2	18/12(14)	10	60

Stage 3

Given to student:

- Chest tube output 150ml/hr, no clots
- ACT 195
- Order for 70 units of protamine, you start infusion at 10mg/min

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 125bpm	70/30(43)	94%	22	25	2.1/1.0	60/32(41)	16	40

14	Recognize low MAP
15	Recognize low CO/CI
16	Recognize low SvO ₂
17	Identify low SvO ₂
18	Recognize probable protamine reaction

Options:

Vasopressors

Volume

Slow/stop protamine

***if volume

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 125bpm	72/31(44)	94%	15	25	2.1/1.0	60/32(41)	19	40

***if vasopressors

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 125bpm	85/50(62)	94%	15	25	2.1/1.0	60/32(41)	19	40

***if protamine slowed/stopped

ECG	A line	SpO ₂	RR	EtCO ₂	CO/CI	PA	CVP	SvO ₂
ST @ 100bpm	90/55(67)	90%	15	33	3.5/1.75	30/20(23)	8	60

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