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Evaluation of a Video-Based Left Ventricular Assist Device Education Program for Certified Registered Nurse Anesthetists and Student Registered Nurse Anesthetists

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Abstract

Background: Video-based educational programs have been proven as a more effective means of instruction than traditional lecture and paper-based formats. Therefore, a video-based left ventricular assist device (LVAD) program was developed to address an identified knowledge gap for the NorthShore University HealthSystem (NSUHS) Certified Registered Nurse Anesthetists (CRNA) and Student Registered Nurse Anesthetists (SRNA).

Objectives: The purpose of this quality improvement project (QIP) was to pilot a newly developed educational video intervention and evaluate the CRNAs' and SRNAs' pre- and post-intervention knowledge difference of the LVAD and the LVAD patient population.

Methods: The sample consisted of CRNAs and SRNAs from NSUHS and the NSUHS School of Nurse Anesthesia. Pre- and post-tests were used and uploaded to Google Forms to maintain anonymity and SPSS was used for data analysis.

Results: The sample consisted of 13 CRNAs and SRNAs. Pre-test scores were found to be less than adequate (M=5.46, SD=1.71). Post-test scores after the educational video intervention did improve (M=6.46, SD=1.90), however, the results were statistically not significant (M=1.00, SD=1.87, -0.13 to 2.13 CI 95%, p=0.078). The Kuder-Richardson-20 (KR20) reliability coefficient for post-test scores was 0.518, which demonstrated adequate internal consistency for the post-test.

Conclusion: The results demonstrated that the LVAD educational video intervention improved post-test scores when compared to pre-test scores. Although the results were statistically not significant and further large-sample studies are needed, this educational video intervention can be a useful tool to bridge the NSUHS CRNAs and SRNAs knowledge gap of LVADs and the LVAD patient population.

Chapter 1. Introduction

Background and Significance of Problem

Heart failure continues to be an epidemic in the United States where it is the fastest growing cardiovascular disorder and the most common reason for hospital admission and readmission among older adults (Jencks, Williams, & Coleman, 2009). From an economical perspective, heart failure costs are an estimated $32 billion annually, which includes the cost of health care services, medications, and missed work days (Heidenreich, 2011). According to the Centers for Disease Control and Prevention (CDC) (2017), approximately 5.7 million individuals in the United States have been diagnosed with heart failure. Nearly half of those who develop heart failure die within the first five years of the diagnosis (Mozaffarian et al., 2014). Although many living with heart failure can survive several years with medication-based treatment modalities, a growing number of individuals will progress to advanced or end-stage heart failure and be evaluated for a heart transplant (Givertz, 2011). For individuals with end-stage heart failure, left ventricular assist devices (LVADs) may be able to offer life-sustaining therapy.

LVADs, which were initially designed as a temporary means to bridge patients to heart transplant, are now increasingly being used as lifetime support or destination therapy (Givertz, 2011). Approximately 2,200 LVADs are implanted in the United States annually and about 4,500 LVADs are implanted annually worldwide (Miller & Guglin, 2013). The most commonly implanted LVADs are second and third generation devices, including the St. Jude Medical HeartMate II (second generation), St. Jude Medical HeartMate 3 (third generation, currently in clinical trial), and the HeartWare HVAD (second generation) (Englert, Davis, & Krim, 2016). The HeartMate II is currently the only device that has been approved by the U.S. Food and Drug

Administration (FDA) for both bridge-to-transplant and destination therapy applications (FDA, 2014).

It is increasingly common for individuals living with an LVAD to undergo non-cardiac surgery. Both cardiac and non-cardiac anesthesia providers will need to become familiar with these devices in order to provide safe and effective care. Perioperative considerations that may influence the anesthetic plan include a thorough LVAD history (settings, indication for placement, duration, complications), anticoagulation use, antibiotic selection, power source and backup batteries, hemodynamic monitoring with arterial line insertion, avoidance of abrupt increases in systemic vascular resistance, treating certain hypotensive episodes with inotropes instead of vasopressors, and other surgical considerations (patient position, surgical approach, electrosurgical grounding pad placement) (Slininger, Haddadin, & Mangi, 2013).

Problem Statement

At the time of project development and implementation, the LVAD program at NorthShore University HealthSystem, Evanston Hospital (NSUHS, EH) was in its preliminary stages of execution (J. Szokol, personal interview, October 27th, 2016). Therefore, the intent of this quality improvement project (QIP) was to help bridge the knowledge gap for the CRNAs at NSUHS, EH by creating an educational video tool that illustrated the special challenges and considerations of the LVAD and the associated patient population.

Project Purpose

The purposes of this quality improvement project were: 1) to produce an educational video for CRNAs based on the most pertinent LVAD components and parameters; and, 2) to pilot a newly developed educational video intervention to evaluate the difference in CRNAs' pre-test and post-test knowledge related to the LVAD and the LVAD patient population.

Clinical Questions

The following clinical questions were addressed in this QIP:

- What components of the LVAD and what LVAD related anesthetic considerations were identified through the multi-disciplinary expert panel feedback as the most relevant to the care of the LVAD patient?
- Did a video-based educational program improve the NSUHS CRNAs and SRNAs knowledge regarding the anesthetic care of the LVAD patient?

Conceptual Framework

The Cognitive Theory of Multimedia Learning (CTML) assumes that a learner's brain attempts to produce logical mental connections between the words, pictures, and auditory information contained within a multimedia presentation, rather than processing each in a mutually exclusive fashion (Gadbury-Amyot et al., 2014; Mayer, 2005; Sorden, 2012). There are three key concepts of the CTML: dual-channels, limited capacity, and knowledge construction (Mayer, 2003). According to Mayer (2003):

- Humans are dual-channel (also known as dual coding) processors, meaning, people have separate channels for processing visual/pictorial information and auditory/verbal information.
- Humans are limited capacity processors, that is people are able to actively process only a small amount of information in each channel at any one time.
- Humans are knowledge constructing processors, so meaningful learning occurs when people attend to relevant incoming information, mentally organize the information in coherent structures, and mentally integrate it with other knowledge.

A multimedia presentation encourages the learner to build a coherent mental representation from the presented material by engaging both visual/pictorial and auditory/verbal channels, then, organizes the information logically and dynamically (Gadbury-Amyot, Purk, Williams, & Van Ness, 2014; Mayer, 2005; Sorden, 2012). Both knowledge retention and knowledge transfer are at their greatest when both visual and auditory channels are engaged by a multimedia presentation simultaneously, such as narration and video, as opposed to text alone.

A companion theory to CTML is Paivio's Dual Coding Theory (DCT). The DCT assumes that the "use of visualization enhances learning and recall, in no small part because images and words are processed at different sites in the central nervous system" (Hartland, Biddle, & Fallacaro, 2008, p. 196). The DCT like the CTML hypothesizes that information is more effectively retained, retrieved, and transferred when it is simultaneously processed through the interconnected linguistic and visual pathways (Hartland et al., 2008).

Hartland and colleagues (2008) utilized the DCT in their study as it is the primary framework addressing the issue of the use of graphic visualizations in cognitive processing. "Video demonstration, unlike words, may have the ability to enliven abstract concepts, demonstrate real-world applications of complex principles, motivate the learner, organize thoughts and actions of highly cognitive processes, and heighten learner attention and interest" (Hartland et al., 2008, p. 197). Moreover, a realistic and relevant video can encourage learners to be active participants in a video-based educational program (Hartland et al., 2008).

Therefore, the CTML and the DCT were selected as the theoretical framework for a LVAD video-based educational program to encourage the NSUHS, EH CRNA's and SRNA's active participation in the education. As active participants in the LVAD video-based education, the belief was that the CRNA's and SRNA's knowledge retention, retrieval, and transfer would be enhanced through simultaneous stimulation of the linguistic and visual pathways associated with the video-based LVAD education.

Chapter 2. Literature Review

A review of existing literature from Academic Search Complete, CINAHL, Education Research Complete, and PubMed was conducted utilizing Boolean operator and search terms: "left ventricular assist device OR LVAD AND video AND education," "video AND anesthesia AND education," "video AND anesthesia AND simulation," "instruction videos AND films," "video simulation," "instruction videos AND films AND anesthesia." Because video based learning is a newer concept, and the second generation LVAD is new device, there was no need to create time parameters for this search. No search results were yielded pertaining directly to video education and simulation for the LVAD, which warrants further investigation of the topic. A plethora of literature was obtained regarding the use of video education and simulation in both healthcare and non-healthcare related education. This literature review will, however, focus only on those studies with a medical purview.

Video-Based Education

The use of technology and video-based learning is a relatively new educational modality that is being adapted into the traditional curricula for many healthcare related specialties. Self-guided, technology-driven, and video-based education has additional benefits over traditional education, which includes enhanced teaching effectiveness, improved knowledge transfer, and developed knowledge and skills retention (Bonnetain, Boucheix, Hamet, & Freysz, 2010; Brydges, Carnahan, Safir, & Dubrowski, 2009; Chi, Pickrell, & Riedy, 2014).

Chi and colleagues (2014) contrasted the learning outcomes between video-based education and the more traditional paper-based education. Both educational approaches presented case studies to dental students in their respective formats. This retrospective cohort study found that the technology driven format was preferable for the dental students when compared to traditional paper-based education. Moreover, the study also indicated that video education had improved knowledge transfer as evidenced by higher mean effectiveness scores as well as significantly improved overall learning outcomes (Chi et al., 2014).

Technology-based education has been shown to improve participant performance in high-fidelity simulations (Bonnetain et al., 2010). Bonnetain and colleagues (2010) compared the performance of medical students on a high-fidelity patient simulator after learning cardiac arrest procedures utilizing computer screen-based simulation versus practical exercises in a traditional class environment. The results of the study indicated that students educated with computer screen-based simulation performed significantly better ($p < 0.001$) on the high-fidelity simulator than students who were educated using more traditional means (Bonnetain et al., 2010). These results were supported by McLain, Biddle, and Cotter (2012), as they found the use of educational video vignettes improved learner recall during high-fidelity simulations over those who were given written case studies.

Woodworth, Chen, Horn, and Aziz (2013) sought to determine the efficacy of video and simulation on ultrasound-guided regional anesthesia. The sample of anesthesia providers were randomly divided into two groups: a video-simulation group and a sham video group (Woodworth et al., 2013). Both groups were given pre- and post-tests, as well as participated at stations to demonstrate ultrasound scanning skills (Woodworth et al., 2013). Though there was no significant difference between the two groups in terms of ultrasound scanning skills, the group taught via video and simulation had significantly improved scores on written exams (Woodworth et al., 2013).

Self-Guided Learning

As more new education is introduced via an online video format, investigators attempt to determine the difference between instructor-led versus self-guided learning. Previous studies found that self-guided learners with clear performance and outcome goals and unrestricted access to educational videos had improved skill retention (Brydges et al., 2009). Brydges and associates (2009) concluded that unrestricted access to an instructional video in addition to goal lists, a simulator, and appropriate instruments were sufficient for the student to independently learn surgical wound closure. Self-guided learners were able to address their own learning needs as they became apparent, which was not true for the control group who accessed instruction in a more traditional format (Brydges et al., 2009).

Learner Attitudes Toward Educational Videos

Kelly, Lyng, McGrath, and Cannon (2009) investigated the effectiveness of, and learner attitudes towards, educational videos teaching clinical nursing skills in comparison to the traditional lecture format. The findings of their study showed that educational videos were an effective complement to the traditional lecture-based education in presenting clinical skills (Kelly et al., 2009). Students had no statistically significant differences in outcomes of knowledge and performance when compared to the traditional lecture format (Kelly et al., 2009). However, the study noted that differences between genders and maturity levels may be present in regard to the learner's attitude toward video education. For example, 1:3 males compared to 1:2 females were favorably disposed to learning through video education (Kelly et al., 2009). Additionally, more mature students tended to respond favorably to video education when compared to less mature respondents (Kelly et al., 2009).

Begum (2015) compared the effectiveness of video-assisted teaching to that of a self-instructional module on quality of life among those living with Type-2 diabetes. The participants were divided into two groups (video-assisted and self-instructional module) and were given pre- and post-tests to determine the efficacy of the teaching methodology (Begum, 2015). Not only did the participants heavily favor video-assisted teaching, the post-test scores were significantly higher for the video-assisted group than for the self-instructional module group (Begum, 2015).

In summary, the literature review rendered supports the use of video-based education over traditional means due to its effectiveness and learner preference in various disciplines. Video-based education on an intricate apparatus, such as the LVAD, could effectively be disseminated among CRNAs to provide safe and effective care to the LVAD patient population. Since, as previously stated, there were no current studies pertaining directly to video education for the LVAD, further research on its usefulness with CRNAs is warranted.

Chapter 3. Method

Quality Improvement Project Design

A pre-test, post-test design was used in this QIP to compare the CRNAs and SRNAs knowledge regarding the LVAD and LVAD patient population before and after the LVAD video education intervention. Independent variables included the number of CRNAs and SRNAs who participated in this QIP, the number of pre-tests completed, and the number of post-tests completed after the video education intervention. The dependent variables included the difference in pre-test and post-test scores and overall impact of the video education on CRNA and SRNA knowledge. The content of the video education, pre-test, and post-test were validated by an expert panel. The pre-test, post-test design was applicable because it demonstrated recall of pertinent information from the video, and allowed the investigators to compare the same participant's responses before and after the intervention. Furthermore, this pre-test, post-test design was suitable because the purpose of this QIP was to evaluate the impact of a video education module in improving the learner's knowledge with the LVAD and the LVAD patient population.

Sample & Setting

For the purposes of this QIP, the CRNAs and SRNAs at NSUHS, EH in Evanston, IL were the population of interest. A convenience sample of volunteer CRNAs and SRNAs from NSUHS, EH were used. Convenience sampling is a non-probability sampling technique where subjects are selected because of their convenient accessibility and proximity to the investigator (Williamson, 2003). Inclusion criteria consisted of CRNAs employed at NSUHS, EH and second or third year SRNAs from the NSUHS School of Nurse Anesthesia who were participating in their clinical practicum. There were no minimum or maximum work experience, specialty, or previous work experience requirements.

Recruitment Procedure

Subjects were recruited and informed of QIP objectives via e-mail. NSUHS, EH CRNA e-mail addresses were compiled with the assistance of Julia Feczko, DNP, CRNA, who was a CRNA at NSUHS, EH and the site clinical coordinator for NSUHS School of Nurse Anesthesia. Dr. Feczko was the third-party who contacted NSUHS, EH CRNAs via e-mail in regard to participation in this QIP. Dr. Feczko was the only person to contact the subjects so that the primary investigators remained blinded to subjects' contact information. The content of the recruitment e-mail can be found in *Appendix A*, which included the purpose of the study, its voluntary and anonymous nature, and a hyperlink to the study. Participants were informed that submission of the pre-test and post-test assumed consent to participate in the QIP. There were no incentives provided to NSUHS, EH CRNAs to participate in this QIP and no negative consequence resulted from non-participation.

Instruments

LVAD education video. The LVAD education video content (*Appendix C*) was developed by the investigators and the content was approved by the committee members – Karen Kapanke, DNP, CRNA (assistant program director for NSUHS School of Nurse Anesthesia) and Julia Feczko, DNP, CRNA. The LVAD education video content was further validated by an expert panel. The expert panel consisted of Todd Novak, MD, a cardiac anesthesiologist at NSUHS, EH; and, three LVAD coordinators from Advocate Christ Medical Center in Oak Lawn, IL: Roxanne Siemeck, MSN, APRN-BC; Kylie Hughes, MSN, ANP-BC, CCRN; and, Nicole Graney, MSN, APRN, CNS-BC. The video was created as a voice over PowerPoint presentation with pictographic and animations included. Since the St. Jude Medical HeartMate II is the only device implanted at NSUHS, EH, the educational video focused solely on this device.

LVAD education video pre-test and post-test questionnaire. The pre-test and post-test instrument was developed by the investigators and consisted of a demographic survey (*Appendix D*), a pre-test (*Appendix E*), and a post-test (*Appendix F)*. The demographic questions included participant's gender, age, years of experience as a CRNA, whether or not they had worked in the realm of cardiovascular anesthesia, and any prior critical care nursing experience. The pre-test and post-test questionnaire was a 10-item, multiple choice test designed to objectively measure the CRNAs knowledge level before and after a LVAD video-based education program. The demographic survey and pre-/post-test tools were submitted to the aforementioned DNP project committee members and expert panel for face and content validity. After review, the revisions recommended by the DNP project committee and expert panel were as follows: grammatical errors; further differentiation and specificity of participant demographics; and, clarification of multiple choice questions and answers. For example, participant age was more narrowly categorized and a question assessing participant's previous critical care experience prior to anesthesia school was added. The instruments were resubmitted to the DNP project committee and expert panel for validation after all changes were made, at which point, the instruments were approved and validated.

Data Collection

Upon receiving confirmation from the NSUHS Research Institute that IRB review was not needed for this QIP, a request for participation was e-mailed to the NSUHS CRNAs as previously outlined. The video education module was open for participation for four weeks with a reminder e-mail sent at two weeks into the data collection period. The primary investigators estimated a response rate of 30%. Participants were sent the recruitment e-mail, which had a hyperlink to the education module, including the information sheet, demographic survey, pre-test, video education, and finally, the post-test. At the completion of the demographic section and the pre-test, the LVAD video education was immediately available to watch in the partcipant's web browser. After viewing the LVAD education video, the participant was taken directly to the post-test. Following the submission of the post-test, the participant was thanked for their submission and the link to the instrument closed.

Data Analysis

Data from the demographic survey, pre-test, and post-test was gathered utilizing Google Forms, an online freeware application. The results were then analyzed in IBM SPSS version 24 to determine the impact of the video education. Using the SPSS software, paired t-test was used to determine the presence of a significant difference between pre-test and post-test mean scores.

Descriptive statistics were used to summarize the sociodemographic characteristics of the CRNA participants.

Protection of Human Subjects

Dr. Julia Feczko was the third-party to contact NSUHS, EH CRNAs via e-mail in regard to QIP participation. Dr. Feczko was the only person to contact the subjects so that the primary investigators remained blinded to the subjects' contact information. Subjects were sent the recruitment e-mail and were linked to the information sheet before beginning the educational module, in which they were made aware that participation in the project was entirely voluntary and that participants could choose to terminate participation at any time.

Anonymity was strictly maintained as no personal information was made public. Participants were informed that no negative consequences would result from participation or non-participation in this QIP. The benefit of participation was increased knowledge about the anesthetic implications of a patient with an LVAD undergoing non-cardiac surgery.

Revised Methodology

Due to a low response rate (2 out of 90, 2.2%) during the initial data collection phase, despite a two-week extension to the original four week data collection period, it was decided with the agreement of the DNP project committee members, that an additional sample was needed. Therefore, recruitment was extended to the second and third year SRNAs attending the NSUHS School of Nurse Anesthesia. The recruitment email was also sent to the CRNAs on the heart team. The inclusion criteria for the SRNAs included current second or third year SRNAs at the NSUHS School of Nurse Anesthesia. Again, there were no minimum or maximum work experience, specialty, or previous work experience requirements and their participation was voluntary.

The same recruitment procedures, instruments, data collection, data analysis, and human subjects' protections were applied to the SRNA and heart team CRNA samples as was applied to the CRNAs. However, several amendments were made to the demographic survey, which included adding a category for current position to delineate second and third year SRNAs, as well as further delineation between CRNAs and heart team CRNA. Furthermore, years of anesthesia experience was modified to include residency experience, and experience working in the setting of cardiovascular anesthesia was modified to include SRNAs. Both the recruitment e-mail and information sheet were also updated to be inclusive of the SRNAs.

Chapter 4. Results

Demographics

A total of thirteen anesthesia providers participated in this study (N=13). All tables and figures depicting data results can be appreciated in *Appendix G*. The demographic data is represented in Table 1. The participants included three CRNAs (23.1%) and ten SRNAs, two of which were in their second year (15.4%) of anesthesia school and eight were in their third year (61.5%). None of the participants reported being heart team CRNAs. All of the participants were female (100%) with a majority aged 26 – 30 years old (53.8%). The majority of participants had 1-3 years of experience providing anesthesia (61.5%), provided anesthesia in the cardiovascular setting (76.9%), and did not work in a cardiovascular intensive care unit (CVICU) prior to anesthesia school (76.9%).

Test Scores

A paired t-test was used to determine the difference in mean values of post-test scores to pre-test scores. The distribution of pre-test and post-test scores can be appreciated in Figure 1. The difference in pre-test scores (M=5.46, SD=1.71) and post-test scores (M=6.46, SD=1.90) were not statistically significant (M=1.00, SD=1.87, CI 95% -0.13 to 2.13, p=0.078). The Kuder-Richardson 20 (KR-20) reliability coefficient was calculated to determine the internal consistency of the pre- and post-tests. The pre-test KR-20 was 0.344 and post-test KR-20 was 0.518.

Test Scores Based on Demographic Data

An independent t-test was used to determine the difference in mean pre-test and post-test scores based on demographic data with two groups. Mean pre- and post-test scores based on whether respondents previously worked in a CVICU can be seen in Figure 2. The difference in mean pre-test scores between those respondents that previously worked in a CVICU and those that did not was not statistically significant (M=0.27, CI 95% -2.32 to 2.85, p=0.825). The difference in mean post-test scores between those respondents that previously worked in a CVICU and those that did not was not statistically significant (M=-0.17, CI 95% -3.04 to 2.70, p=0.901). Mean pre- and post-test scores based on whether respondents provided anesthesia in a cardiovascular setting can be seen in Figure 3. The difference in mean pre-test scores between those respondents that provided anesthesia in a cardiovascular setting and those that did not was statistically significant (M=2.77, CI 95% 0.94 to 4.60, p=0.007). The difference in mean post-test scores between those respondents that provided anesthesia in a cardiovascular setting and those that did not was not statistically significant (M=1.90, CI 95% -0.68 to 4.48, p=0.133).

A one-way ANOVA test was used to compare the mean pre-test and post-test scores based on demographic data with three or more groups. Mean pre- and post-test scores based on respondents current position can be seen in Figure 4. The difference in mean pre-test scores between current position groups was not statistically significant [F(2,10)=3.65, p=0.065]. The difference in mean post-test scores between current position groups was not statistically significant [F(2,10)=0.15, p=0.866]. Mean pre- and post-test scores based on respondents years of anesthesia experience can be seen in Figure 5. The difference in mean pre-test scores between years of anesthesia experience groups was not statistically significant [F(3,9)=2.60, p=0.117]. The difference in mean post-test scores between years of anesthesia experience groups was not statistically significant [F(3,9)=0.20, p=0.892]. Mean pre- and post-test scores based on respondents age range can be seen in Figure 6. The difference in mean pre-test scores between age range groups was not statistically significant [F(3,9)=1.56, p=0.265]. The difference in mean post-test scores between age range groups was not statistically significant [F(3,9)=0.99, p=0.440]. None of the one-way ANOVA tests produced statistically significant results (p<0.05).

Pre-Test and Post-Test Breakdown

Each pre-test and post-test question was analyzed in detail. The percent of correct responses for each question can be found on Table 2. The questions with the lowest pre-test scores were Questions 3 (30.8%), 7 (30.8%), 9 (38.5%), and 10 (15.4%). The questions with the lowest post-test scores were Questions 9 (30.8%) and 10 (15.4%). The questions with the highest pre-test scores were questions 4 (92.3%) and 6 (92.3%).

Chapter 5. Discussion

The purpose of this quality improvement project was to create a video education program that described the most pertinent components of the LVAD and its anesthetic implications in order to improve the CRNA's and SRNA's knowledge and provide optimal anesthetic care to this patient population. Improvement in CRNA's and SRNA's knowledge was determined using a pre-test and post-test design. The video education program, pre-test, and post-test was created by the researchers using evidence-based research and approved by the DNP project committee and an expert panel. It was found that post-test scores (M=6.46) improved compared to pre-test scores (M=5.46) after viewing the video education program (p=0.078). These findings were congruent with the findings of the literature review (Bonnetain, Boucheix, Hamet, & Freysz, 2010; Brydges, Carnahan, Safir, & Dubrowski, 2009; Chi, Pickrell, & Riedy, 2014). These studies found that video-based education was an effective teaching method because it improved participants' knowledge better than traditional teaching methods.

The participants completed a demographic questionnaire prior to completing the pre- and post-test. The majority of participants were SRNAs, were 26 – 30 years old, had 1 – 3 years of experience providing anesthesia, provided anesthesia in the cardiovascular setting, and did not work in a CVICU prior to anesthesia school. All of the participants were female and none reported themselves as heart team CRNAs. The relatively small sample size and the lack of diversity may have affected the results of this quality improvement project. The results of this study cannot be generalized to the entire population of CRNAs and SRNAs due to low statistical power. Since more SRNAs participated than CRNAs, the SRNA's abbreviated clinical anesthesia experience compared to the CRNAs may have produced lower average pre-test scores. Furthermore, if heart team CRNAs participated in the QIP, average pre-test scores may have been higher, since their level of cardiovascular anesthesia knowledge is higher than the average anesthesia provider.

The Kuder-Richardson 20 (KR-20) reliability coefficient was calculated to determine the internal consistency of the pre-tests and post-tests. The pre-test KR-20 demonstrated that the test was relatively difficult. This was most likely because the information in this video education was very specific and the information was pertinent to those anesthesia providers who worked in the cardiovascular setting. The post-test KR-20 demonstrated that the test became relatively easier after watching the video education. This showed that the CRNA's and SRNA's level of knowledge had improved. This demonstrated that the video-based education program effectively improved the CRNA's and SRNA's knowledge regarding the anesthetic care of the LVAD patient.

A paired t-test was used to determine the difference in mean values of pre-test scores to post-test scores. The paired t-test results demonstrated that post-test scores improved compared to pre-test scores, but this improvement was not statistically significant. Statistical significance may have been demonstrated with a larger, more diverse sample of participants.

In addition to the paired t-test, one-way ANOVA tests were used to compare the mean pre-test and post-test scores based on demographic data with three or more groups. It is important to note, none of the ANOVA test results demonstrated statistical significance. The lack of statistical significance in the results may have occurred due to the relatively small sample size. Despite the lack of statistical significance, differences in pre-test and post-test scores based on demographic data could still be appreciated. Mean pre-test and post-test scores were relatively similar for those participants who previously worked in a CVICU prior to anesthesia school. This demonstrated that prior CVICU experience did not translate into improved cardiovascular anesthesia knowledge. This is contrary to the researchers' hypothesis that prior CVICU experience improved cardiovascular anesthesia knowledge.

Mean pre-test and post-test scores were higher for those who provided anesthesia in a cardiovascular setting. This demonstrated that prior experience providing anesthesia in a cardiovascular setting translated to improved cardiovascular anesthesia knowledge. Those that provided anesthesia in a cardiovascular setting had a better understanding of cardiovascular physiology and the anesthetic implications of the LVAD, compared to those providers who did not provide anesthesia in a cardiovascular setting. This corresponded to the researchers' hypothesis that prior experience providing anesthesia in a cardiovascular setting improved cardiovascular anesthesia knowledge.

Mean pre-test scores improved with a more advanced position (i.e. second-year SRNAs < third year SRNAs < CRNAs). Second-year SRNAs had the least amount of experience administering anesthesia in the cardiovascular setting, while CRNAs had the most experience. This demonstrated that more experience in cardiovascular anesthesia translated to improved cardiovascular knowledge. This corresponded to the researchers' hypothesis that the increased amount of experience providing anesthesia in a cardiovascular setting improved cardiovascular anesthesia knowledge. Furthermore, mean post-test scores between the three positions plateaued after viewing the video-based LVAD education, which demonstrated improved participant knowledge.

Mean pre-test scores increased with the number of years of anesthesia experience of the participants. This corresponded to the researchers' hypothesis that increased number of years of anesthesia experience improved cardiovascular anesthesia knowledge. Mean pre-test scores peaked at 4 – 6 years of experience, but mean pre-tests scores began to drop thereafter. Those participants with 4 – 6 years of experience were recent CRNA graduates. New CRNA graduates had the tendency to take on the most challenging cases, which included cardiovascular anesthesia. This may have explained why mean pre-test scores peaked at 4 – 6 years of experience. Seasoned CRNAs had the tendency to not take on the most challenging cases and usually did not administer anesthesia in the cardiovascular setting. The participant with greater than 10 years of experience may have had lower mean pre-test scores for this reason. Since only one participant reported having greater than 10 years of experience, the result may have been due to an outlier. A larger, more diverse sample may have increased the statistical power of this QIP and clarified assumptions made by the researchers. Mean post-test scores plateaued between groups with varying years of anesthesia experience, which demonstrated that the CRNAs and SRNAs level of cardiovascular anesthesia knowledge improved after viewing the video-based LVAD education.

Mean pre-test scores increased with the age of the participant, peaked at the 31 – 35 year age range, and then decreased thereafter. Those participants that reported being 31 – 35 years old may have been SRNAs or recent CRNA graduates who posess the most up-to-date cardiovascular anesthesia knowledge and may have recent experience in the setting of cardiovascular anesthesia. This would then translate into improved cardiovascular anesthesia knowledge and resulted in improved pre-test scores, which corresponds with the researchers' hypothesis. Mean pre-test scores were reduced after the 31 – 35 year age range and was the lowest for the 41-45 year age range. This may have been due to the tendency that more seasoned CRNAs take on less challenging cases, and therefore have diminished level of cardiovascular anesthesia knowledge. It is important to note that only one participant reported being 41 – 45 years old and the subsequent result may have been an outlier.

Pre-test and post-test questions were analyzed in detail to determine efficacy in improving the CRNA's and SRNA's knowledge regarding anesthetic implications for patients with an LVAD. Pre-test questions 4 and 6 had the highest number of correct responses (*Appendix E*). Question 4 reflected the topic of hemodynamic function of an LVAD and question 6 reflected intraoperative considerations for LVAD patients. This demonstrated that the participants had prior knowledge in these areas. Pre-test questions 3, 7, 9, and 10 had the lowest number of correct responses (*Appendix E*). In the post-test, question 3, which reflected knowledge regarding external chest compressions in the event of a cardiopulmonary event, and question 7, which reflected the necessity of a rapid sequence intubation for LVAD patients undergoing general anesthesia, improved significantly (*Appendix F*). This demonstrated that the video-based education improved the CRNA's and SRNA's knowledge in these areas. Conversely, questions 9 and 10 did not show a significant improvement in the post-test (*Appendix F*). Question 9 reflected appropriate interventions in the post-operative phase following the surgical implantation of an LVAD and question 10 reflects bloodflow through a Heartmate II LVAD. These questions may have been very difficult, demonstrating that the video-based education may not have effectively conveyed the knowledge to the participants. Recommendations for future research should include re-evaluation of the video-based education, making necessary changes to improve CRNA's and SRNA's knowledge in these two areas.

Limitations

One limitation of this QIP was a small, homogenous convenience sample. The initial attempt to recruit CRNAs at NSUHS, EH proved unsuccessful at achieving the desired number of respondents. Therefore, the educational module was opened to second and third year SRNAs and an additional recruitment e-mail was sent to the heart team CRNAs. Though more responses were obtained with the inclusion of the SRNAs, no heart team CRNAs participated and the total number of responses fell short of the author's goal sample size. Had SRNAs been included from the outset of data collection, the total number of responses might have been dramatically higher, potentially providing statistical significance to the results.

Furthermore, the small sample size may be attributable to CRNA survey burnout at NSUHS, EH. Due to its affiliation with the School of Nurse Anesthesia, CRNAs at NSUHS, EH are inundated with requests for participation in student projects in addition to performing their responsibilities as staff CRNAs and clinical faculty. It is important to note that all staff CRNAs must complete hospital assigned annual required education modules as well as clinical competency modules, which account for a substantial time commitment on their own.

An additional factor potentially affecting the project's sample size included the highly specialized nature of the content included in the video-based education module. The anesthetic considerations of LVAD patients may not be pertinent to CRNAs who rarely care for LVAD patients. Furthermore, NSUHS, EH has a team of cardiac trained CRNAs who are primarily responsible for the anesthetic management of cardiovascular cases. This team of CRNAs comprise a small subset of the CRNA staff. These CRNAs previously (prior to the implementation of this QIP) received an in-person lecture on the topic of LVADs from Dr. Novak, a content expert utilized for validation of this QIP's educational content and instruments. Therefore, the heart team CRNAs may not have felt compelled to complete additional education for a familiar patient population.

Ultimately, the affect of a small, homogenous sample is the inability to generalize the results of the study. Other factors affecting generalizability included the lack of gender diversity with zero male respondents and possible bias created with non-random convenience sampling. The inability to generalize results is less of a concern with this QIP, as the aim of the QIP was to affect change in a specific population—specifically the NSUHS, EH CRNAs and SRNAs. However, this would pose a concern for future research attempting to broadly generalize research results.

Another limitation of this QIP was the participant's substantial time commitment to complete the video-based education module. Though the video-based education module was developed with the participant's time commitment in mind, the video-based education required greater than 15-minutes of the participant's time. This level of commitment may have been prohibitive to CRNAs and SRNAs to complete without encroaching on their personal time at home.

Lastly, a limitiation that was encountered by the authors was the inability to implement the QIP as originally intended at Northwestern Memorial Hospital (NMH) in Chicago, IL. NMH is a large academic hospital, and one of the busiest LVAD implanting hospitals in the Chicagoland area. Initially, a significant knowledge gap was identified at NMH related to CRNAs and their understanding of the anesthetic considerations for the LVAD. Because of this knowledge gap, the CRNAs were highly motivated to learn about LVAD related concepts especially since it had become increasingly common for CRNAs to be asked to provide anesthesia for LVAD patients during non-cardiac procedures. Unfortunately, the QIP proposal was rejected by NMH's Nursing Research and Evidence-Based Practice Committee. Thus, the QIP's focus was shifted away from the CRNAs at NMH, and ultimately to the CRNAs at NSUHS, EH.

Retrospectively, the knowledge gap that existed with the CRNAs at NMH was also appreciated in the NSUHS SRNAs. However, the CRNAs at NSUHS, EH had received previous education on the LVAD, thus, making the knowledge gap less pronounced or possibly non-existant. Therefore, the better participation by the SRNAs and the minimal participation by the CRNAs could be explained by the fact that the video-based LVAD education was actually addressing the learning needs of the SRNAs. It is possible that any increased participation of the NSUHS SRNAs may have been attributable to feelings of obligation. Second year SRNAs may have felt obliged to participate in this QIP due to the fact that the researchers were third year NSUHS SRNAs who may have been seen as potential mentors or superiors in their program of study. Furthermore, fellow third year NSUHS SRNAs could view participation in this QIP as a tacet quid pro quo arrangement of mutual project participation.

Recommendations for Future Research

An extensive literature review was conducted for this QI project, and no results were found relating specifically to video-based education and the LVAD. Therefore, the topic of this QIP is ripe for future investigation. Future studies conducted on this topic would benefit from a larger sample size. This could be achieved by implementing the study at a clinical facility where the information presented would be applicable to a larger number of CRNAs. For example, an established LVAD implanting center, such as NMH, has a large LVAD patient population undergoing non-cardiac procedures and are cared for by CRNAs who have not received specialized LVAD training.

Another recommendation for future studies includes avoiding project implementation at NSUHS, EH and other facilities affiliated with a school of nurse anesthesia. The staff CRNAs at such a facility are at a higher risk for experiencing a level of burnout from over sampling for student projects. This could, as previously discussed, lead to low study response rates. On the other hand, implementation of a similar project at a facility associated with a school of nurse anesthesia would be ideal if the target population was SRNAs, as this could improve SRNA response rates.

Finally, future studies evaluating an LVAD education program for CRNAs and SRNAs should consider the program's content and its length. The LVAD is a highly complex device, requiring substantial time to cover its many intricacies in an educational program. However, elaborating on the many complexities of the device is not necessary for non-cardiac trained CRNAs and SRNAs to provide safe care to this patient population, and may actually function as a barrier to their participation in an educational program. Therefore, it is recommended that future studies on LVAD education program be developed to provide basic knowledge of the device and the associated physiologic changes impacting anesthesia care so that it is applicable to all anesthesia providers. This will also help in keeping the educational content to a reasonable length that is not prohibitive to study participation.

Conclusion

Though the results of this project did not show a statistically significant improvement in post-test scores when compared to the pre-test scores, an improvement in post-test scores was noted. Therefore, a video-based LVAD educational module could be used as part of the NSUHS, EH CRNA's annual LVAD competency. The video-based LVAD educational module could also be used to supplement a SRNA's didactic and clinical cardiovascular training, solidifying LVAD related concepts learned in the classroom and perioperatively.

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Appendix A

Recruitment E-mail

Dear Certified Registered Nurse Anesthetist and Student Registered Nurse Anesthetist,

Our names are Andrew Gause and Zain Rehman. We are third year nurse anesthesia trainees implementing a quality improvement (QI) project as part of our doctoral work with the NorthShore University HealthSystem School of Nurse Anesthesia and DePaul University. We are conducting this QI project to evaluate the effectiveness of a video-based left ventricular assist device (LVAD) educational program at increasing LVAD related knowledge in the Nurse Anesthetist and Student Nurse Anesthetist.

Over the next four weeks, you may participate in this QI project at your convenience. Your participation is both voluntary and confidential. You may choose to terminate your participation in this project at any time. However, once the surveys and evaluative tools are submitted, we will be unable to remove your responses from the data, as they are anonymous and therefore will not be identifiable.

Below you will find a hyperlink to the educational program, which will take you first to an information sheet. Please be sure to review this information sheet prior to proceeding to the subsequent demographic survey, pre-test, video education module, and the post-test.

We thank you in advance for your participation.

Sincerely,

Andrew Gause, BSN, RN, NAT-3
Zain Rehman, BSN, RN, NAT-3
NorthShore University HealthSystem
School of Nurse Anesthesia

<Hyperlink to Pre-test>

Appendix B

Information Sheet

INFORMATION SHEET FOR PARTICIPATION IN QUALITY IMPROVEMENT PROJECT:

Evaluation of a Video-Based Left Ventricular Assist Device Education Program for Certified Registered Nurse Anesthetists

Principal Investigators: Andrew Gause, BSN, RN; Zain Rehman, BSN, RN

Institution: DePaul University, USA

Collaborators: NorthShore University HealthSystem School of Nurse Anesthesia: Karen Kapanke, DNP, CRNA and Julia Feczko, DNP, CRNA

Dear Certified Registered Nurse Anesthetist and Student Registered Nurse Anesthetist,

Our names are Andrew Gause and Zain Rehman. We are third year nurse anesthesia trainees conducting a quality improvement (QI) project as part of our doctoral work with the NorthShore University HealthSystem School of Nurse Anesthesia and DePaul University. Our QI project will evaluate the effectiveness of a video-based left ventricular assist device (LVAD) educational program at increasing LVAD related knowledge in the Certified Registered Nurse Anesthetist (CRNA) and Student Registered Nurse Anesthetist (SRNA). We are asking you to participate in the research project because you are currently either a CRNA or SRNA at NorthShore University HealthSystem Evanston Hospital, a LVAD implanting facility. If you agree to participate in this research project, you will be asked to complete a short demographics survey, watch an approximately 15-minute video-based LVAD education, and complete a short pre-education and post-education assessment tool. The pre- and post-education surveys will include questions to assess one's knowledge related to basic LVAD concepts. This video-based LVAD education will take approximately 15-minutes of your time. The demographic survey and evaluative tools should take no more than 15 additional minutes.

Your participation in this QI project is voluntary, which means you can choose not to participate. The submission of a survey will assume a form of voluntary agreement to participate in the research project. If for any reason you decide to no longer participate at any time, there will be no negative consequences. You can withdraw your participation at any time prior to submitting your survey. If you change your mind later while answering the survey, you may simply exit the survey. Your decision whether or not to participate will have no effect upon your employment or status within the NorthShore University HealthSystem. Once you submit your responses, we will be unable to remove your data later from the QI project because all data is anonymous and will not be identifiable.

If you have questions, concerns, or complaints about the QI project, or if you want to get additional information please contact Andrew Gause at andrewgause@mac.com or Zain Rehman at zain_2783@yahoo.com.

If you have questions about your rights as a research subject you may contact Susan Loess-Perez, DePaul University's Director of Research Compliance, in the Office of Research Services at 312-362-7593 or by e-mail at sloesspe@depaul.edu. You may also contact DePaul's Office of Research Services if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.

You may keep (or print) this form for your records.

Appendix C

LVAD Video Education Transcript Outline

Objectives
- Provide a brief overview heart failure and the role of the LVAD as a treatment modality
- Review the key components, pump mechanics, and parameters of the HeartMate II
- Discuss LVAD specific perioperative anesthetic considerations during cardiac and non-cardiac surgeries
- Review three significant complications of the HeartMate II

Background
- Heart failure (HF) is a leading cause of morbidity and mortality in the United States. Annually, over 5 million people are diagnosed with HF in the US alone. From an economics perspective, HF related treatments are estimated to cost $32 billion each year.
- HF is a multifaceted disease process.
- For those refractory to traditional heart failure therapies, there are alternative therapeutic options, which include left ventricular assist device (LVAD) and heart transplant. Due to lack of organ donors, LVADs that were once used to bridge a patient to a heart transplant are now being used for destination therapy.

HeartMate II
- The St. Jude Medical HeartMate II is a 2nd generation LVAD. It is the most commonly implanted LVAD in United States, and its the only device that’s FDA approved for both bridge-to-transplant and destination therapy. The HeartMate II is the primary LVAD implanted at Evanston Hospital, so it will be the focus of this educational program. It is important to note that only destination therapy performed at Evanston Hospital.

HeartMate II Components
- The HeartMate II consists of 3 primary components, the pump, the electronic controller, and a power source.
- The pump is implanted in a surgically created pre-peritoneal pocket above the patient's diaphragm.
- The electronic controller is a small computer that controls the workings within the pump, and it is connected to the pump via a percutaneous lead that is tunneled from the pump through the abdomen and out to the controller.
- The power sources for the HeartMate II are AC (wall power) and 2 lithium ion batteries connected to the external electronic controller. Two batteries must be connected at all times even when connected to AC power, to function as a backup in the event of AC power failure. The batteries, which drain simultaneously, provide up to 12 hours of battery life under normal pump operating conditions.

HeartMate II Pump Mechanics
- The HeartMate II provides unidirectional, continuous axial flow through a valveless pump. As can be seen in the images to your right, blood is received from the left ventricle through an inflow cannula. It then passes through an inlet stator, which straightens out turbulent blood flow to be delivered to the rotor. The blood passes through the rotor and over an outlet stator, which converts the blood from radial flow back to axial flow, and is then delivered to ascending aorta through outflow graft

HeartMate II Pump Mechanics (Continued)

- The HeartMate II is afterload sensitive, meaning that as one's systemic blood pressure changes, the pump flow will change. The pump's flow follows the native cardiac pulse and is primarily dependent on the pressure differential across the pump (P_{aortic} - P_{LV}). Thus, pump flow will vary in systole and diastole.
- On the cellular level the LVAD alters the myocardium and decreases the size of cardiomyocytes. In turn, it helps to improve myocardial function and decreases cell death.

HeartMate II Parameters

- The following 4 parameters are the parameters shown on the HeartMate II clinical screen. An image of the clinical screen will be shown in the subsequent slide.
- The pump flow is an estimate of the blood flow out of the pump based on the pump speed and the amount of power being provided to the pump motor under normal operating conditions
- The pump speed, which is shown in revolutions per minute (RPM), matches the actual speed of the pump rotor within +/- 100 RPM under normal conditions. The rotor speed is set at a fixed RPM. The optimum pump speed is often determined via a "ramp study," in which the rotor speed is gradually reduced and then increased under echocardiographic visualization to determine the speed at which there are no signs of worsening HF nor signs over LV decompression.
- The pulsatility index (PI) is a measurement of the increased pump flow during systole due to the increased ventricular pressure during ventricular contraction. The PI is average over 15 seconds and this is the value that is displayed on the clinical screen.
- Normal PI values are 3.5 - 6. Increased PI values tell us that there is more ventricular filling and higher pulsatility, therefore, less support is being provided by the pump. Conversely, decreased PI values indicate less ventricular filling and lower pulsatility, and thus, more support provided by the pump.
- The pump power is the amount of power being provided to the pump motor. Normal pump power ranges from 0 - 25.5 watts.

Preoperative Considerations

- The following are general preoperative considerations for LVAD patients undergoing both cardiac and non-cardiac procedures.
- First, it is important that the LVAD care team is notified upon patient arrival to hospital. The LVAD care team is an invaluable resource when caring for an LVAD patient as they follow these patient on a day-to-day basis and can help to fill in the gaps since the patient's last anesthetic.
- A full set of preoperative labs should be drawn, including CBC, CMP, liver function test, coagulation studies, etc.
- Ensure blood is available for transfusion
- When the patient arrives to the hospital, they should connect to AC power ASAP. It is important to verify remaining power on a patient's batteries, as the battery is always the backup power source in the event of AC power failure. All LVAD patients are trained to bring extra batteries, but this is sometimes overlooked when coming to the hospital.
- Upon patient arrival to the hospital, infectious disease should be notified. LVAD patients will at times have a complicated infectious disease history and need very specific perioperative antibiotic to coverage against specific microorganisms.
- Patients with HF or LVAD will most likely be on some form anticoagulation. If possible, Coumadin, aspirin, and Plavix should be discontinued in advance. If necessary, a patient may

be bridged with a continuous Heparin gtt. Patients with an elevated INR undergoing urgent or emergent surgeries may need anticoagulant reversal. This can be accomplished with Vitamin K, FFP, or PCCs (KCentra).

Intraoperative Considerations

- The following are general intraoperative considerations for LVAD patients undergoing both cardiac and non-cardiac surgeries.
- Lines & monitors: Standard ASA monitors will be used, though it is important to note that the pulse ox is not always reliable due to non-pulsatile flow associate with the LVAD. One large-bore PIV should be placed preoperatively. The anesthesia provider should assess if arterial line is indicated. They are often not needed in non-cardiac surgeries. NIBP can be monitored with sphygmomanometer and a Doppler of the brachial artery signal. LVAD patients have a narrow pulse pressure. The mean arterial pressure is a fairly accurate hemodynamic value in NIBP measurement.
- All post-LVAD implantation patients should be considered to have a full stomach. Therefore, all intubations should be performed following rapid sequence induction

Intraoperative Considerations (Continued)

- Electromagnetic interference may effect LVAD function; therefore, MRI is contraindicated in patients with an LVAD. Both monopolar and bipolar electrocautery may be used on patients with an LVAD, though bipolar is preferred.
- EMI can trick an AICD into delivering a shock. So, it is important to turn off all therapies, including anti-tachycardia pacing and shock preoperatively. External defibrillator pads should be applied in the OR.
- Another intraoperaitve consideration is CPR. If CPR is needed, standard ACLS protocols should be used with one caveat, chest compressions are contraindicated during CPR due to potential for dislodging the LVAD inflow cannula and outflow graft.

Intraoperative Considerations (Continued)

- As with any patient, intraoperative hemodynamic stability is the anesthetic goal. LVAD patients are preload and afterload dependent and are less able to compensate to changes in preload and afterload.
- Normovolemia should be maintained as best as possible. IV fluids should be administered judiciously in the hypovolemic LVAD patient, especially in the setting of RV dysfunction or failure. Crystalloids, colloids, or blood products can be administered, as indicated.
- If vasopressors are needed, phenylephrine and ephedrine IVP may be used. Low-dose vasopressin is preferred over norepinephrine due to its minimal influence on pulmonary vascular resistance
- Nitroglycerin or Nitroprusside IV may be given to reduce afterload

Intraoperative Considerations (Continued)

- Surgical patient positioning can affect pump function.
- Lateral decubitus during one lung ventilation may cause hypoxia and hypercarbia, in turn straining the RV. Trendelenburg causes increased venous return to the heart, resulting in increased rate of LVAD filling, pumping, and output. Reverse Trendelenburg will then result in decreased venous return to pump and less output.

Intraoperative Considerations (Continued)

- Additional considerations for patients undergoing LVAD implantation include:
- Additional lines & monitors:
    - SVO2 Swan-Ganz catheter with introducer for LVAD implantation

  - Pre-induction arterial line
  - Possible IABP if used for pre-operative hemodynamic optimization
  - TEE
  - Cerebral oximetry
- Inhaled nitric oxide is used to reduce RV afterload through pulmonary vasodilation
- It is also important to set up pumps and have pre-drawn syringes ready at the beginning of the case.

Postoperative Consideration

- Bleeding is the most common acute and chronic complication in LVAD patients. In the immediate postoperative period following LVAD implantation, surgical bleeding should be closely monitored as well as signs for cardiac tamponade. Postoperative coagulation studies should be ordered and any derangements should be treated as needed. Bleeding is also a chronic complication with LVADs, including GI bleeds, hemorrhagic strokes, etc. LVAD patients are frequently seen in the GI clinic for this reason. Outpatient coagulation studies are monitored weekly in LVAD patients on Coumadin

Review of Perioperative Considerations

- Preoperative Considerations
  - Discuss case with LVAD care team
  - Perform thorough preoperative evaluation (consider status of LVAD; co-morbidities; laboratory studies)
  - Ensure reliable power source for device
  - Infection prevention (consult ID for appropriate ATB coverage)
  - Anticoagulation management (as indicated, DC anticoagulants; bridge with IV heparin gtt; reverse anticoagulation)
  - Optimize RV function
  - Treat arrhythmias
- Intraoperative Considerations
  - Lines and monitors as indicated for procedure
  - Assume full stomach (rapid sequence induction preferred)
  - Recognize EMI (bipolar electrocautery best; turn off AICD and use R2 pads)
  - Maintain hemodynamics (judicious fluids; vasopressors → low-dose vasopressin available; vasodilators for afterload reduction)
- Postoperative Considerations
  - Assess for bleeding (clinical assessments, laboratory values)
  - Assess fluid status (intake, output, clinical assessments)
  - Continue antibiotics as needed
  - Initiate postoperative anticoagulation when appropriate

HeartMate II Troubleshooting

- An inflow cannula or outflow graft obstruction will present with↓ pump flow, ↓ PI, ↓ pump power.
- A kink in the outflow graft or blockage of the inflow cannula results in an increased pressure difference across the pump → decreased flow
- Location of the flow obstruction cannot be determined by pump parameters alone. A TEE is needed to determine the etiology of the obstruction.

HeartMate II Troubleshooting (Continued)

- A PI event is described as a +/- 45% change from the previous 15 second PI average. As you might recall, a normal PI 3.5 – 6
- A low PI indicates a greater amount of support being provided by the pump
- A high PI indicates a lesser amount of support being provided by the pump or more native heart function
- Not all PI events are true suction events
- Suction event is a physical structure causing an occlusion to the inlet cannula of the LVAD. This is often the movement of the intraventricular septum toward the inflow cannula of the LVAD. This typically occurs when the LV is excessively decompressed.
- Prior to chest closure, a suction event may result in the entrainment of a catastrophic amount of air into chest. A suction event may also cause significant arrhythmias, improved after the termination of the suction event.
- All suction events are PI events
- Treatments include:
    - Decrease pump speed
    - Assess fluid volume status and administer fluids as needed
    - Assess RV function and treat RV dysfunction and failure
- If chest is closed, may need re-exploration for tamponade or inlet cannula malposition

Appendix D

LVAD Video Education Demographic Data

Demographic Data

Gender: □ Male □ Female

Age range:

□ < 21 years old
□ 21 – 25 years old
□ 26 – 30 years old
□ 31 – 35 years old
□ 36 – 40 years old
□ 41 – 45 years old
□ 46 – 50 years old
□ 51 – 55 years old
□ 56 – 60 years old
□ > 60 years old

Current position:

□ SRNA – second year
□ SRNA – third year
□ CRNA
□ CRNA – heart team

Years of anesthesia experience (including residency):

□ < 1 year
□ 1 – 3 years
□ 4 – 6 years
□ 7 – 10 years
□ > 10 years

Have you worked in the setting of cardiovascular anesthesia as either a CRNA or SRNA?

□ Yes □ No

Have you worked in a cardiovascular intensive care unit prior to anesthesia school?

□ Yes □ No

Appendix E

LVAD Video Education Pre-Test

Pre-Test: Please complete **PRIOR** to watching the video education. Choose the best answer.

1. In general, what does the pulsatility index represent?
   a Pulse rate averaged over 60 seconds
   b Amount of assistance provided by the LVAD
   c Cardiac output prior to receiving an LVAD based on patient's body surface area
   d None of the above
2. The HeartMate II is not MRI safe.
   a True
   b False
3. In the event of cardiopulmonary arrest in relation to a patient with an LVAD, external chest compressions are:
   a Contraindicated
   b Performed in the same manner as for a patient without an LVAD
   c Occasionally performed based on the clinical judgement of the provider
   d None of the above
4. Hemodynamic function for a patient with an LVAD is primarily dependent upon:
   a Preload and afterload
   b LVAD battery life
   c Patient position
   d None of the above

5. External defibrillation is contraindicated in an LVAD patient?
   a. True
   b. False
6. In regards to intraoperative considerations for LVAD patients, the anesthesia provider must:
   a. Secure a reliable power source to the LVAD for the duration of the surgery
   b. Confirm appropriate preoperative antibiotic administration
   c. Both A and B
   d. None of the above
7. General anesthesia for a patient with an LVAD should include:
   a. Insertion of a laryngeal mask airway, when appropriate
   b. Rapid sequence intubation
   c. Pulmonary catheter insertion for accurate intraoperative hemodynamic evaluation
   d. None of the above
8. The following is true regarding the HeartMate II LVAD:
   a. It is a valveless device
   b. It is afterload independent
   c. Pump flow varies over the cardiac cycle
   d. a, b, and c are true
   e. a and c are true
9. The most appropriate statement regarding the immediate postoperative phase after placement of an LVAD is:

a. Deviation of the intraventricular septum to the right on echocardiography signifies impending right ventricular failure
b. Maintaining afterload with vasoconstrictors is important to ensure adequate LVAD flow
c. If the patient experiences a "PI event," then a fluid bolus may need to be administered
d. Patients should immediately be anticoagulated because the risk of thromboembolism outweighs the risk of bleeding

10. Blood flow to the HeartMate II takes the following path: left ventricle → outflow graft → inlet stator → rotor → outlet stator → inflow cannula → ascending aorta:
    a. True
    b. False

Appendix F

LVAD Video Education Post-Test

Post-Test: Please complete **AFTER** watching the video education. Choose the best answer.

1. In general, what does the pulsatility index represent?
   a Pulse rate averaged over 60 seconds
   b Amount of assistance provided by the LVAD
   c Cardiac output prior to receiving an LVAD based on patient's body surface area
   d None of the above
2. The HeartMate II is not MRI safe.
   a True
   b False
3. In the event of cardiopulmonary arrest in relation to a patient with an LVAD, external chest compressions are:
   a Contraindicated
   b Performed in the same manner as for a patient without an LVAD
   c Occasionally performed based on the clinical judgement of the provider
   d None of the above
4. Hemodynamic function for a patient with an LVAD is primarily dependent upon:
   a Preload and afterload
   b LVAD battery life
   c Patient position
   d None of the above

5. External defibrillation is contraindicated in an LVAD patient?
   a True
   b False
6. In regards to intraoperative considerations for LVAD patients, the anesthesia provider must:
   a Secure a reliable power source to the LVAD for the duration of the surgery
   b Confirm appropriate preoperative antibiotic administration
   c Both A and B
   d None of the above
7. General anesthesia for a patient with an LVAD should include:
   a Insertion of a laryngeal mask airway, when appropriate
   b Rapid sequence intubation
   c Pulmonary catheter insertion for accurate intraoperative hemodynamic evaluation
   d None of the above
8. The following is true regarding the HeartMate II LVAD:
   a It is a valveless device
   b It is afterload independent
   c Pump flow varies over the cardiac cycle
   d a, b, and c are true
   e a and c are true
9. The most appropriate statement regarding the immediate postoperative phase after placement of an LVAD is:

a Deviation of the intraventricular septum to the right on echocardiography signifies impending right ventricular failure

b Maintaining afterload with vasoconstrictors is important to ensure adequate LVAD flow

c If the patient experiences a “PI event,” then a fluid bolus may need to be administered

d Patients should immediately be anticoagulated because the risk of thromboembolism outweighs the risk of bleeding

10. Blood flow to the HeartMate II takes the following path: left ventricle → outflow graft → inlet stator → rotor → outlet stator → inflow cannula → ascending aorta:

c True

d False

Appendix G

Data Table and Figures

Table 1. Demographic Data

		Frequency	Percentage (%)
Gender	Male	0	0.0
	Female	13	100.0
Age	26 – 30 years old	7	53.8
	31 – 35 years old	2	15.4
	36 – 40 years old	3	23.1
	41 – 45 years old	1	7.7
Current Position	CRNA	3	23.1
	SRNA - second year	2	15.4
	SRNA - third year	8	61.5
Years of Experience Providing Anesthesia	< 1 year	2	15.4
	1 – 3 years	8	61.5
	4 – 6 years	2	15.4
	> 10 years	1	7.7
Provided Anesthesia in the Cardiovascular Setting	No	3	23.1
	Yes	10	76.9
Worked in a CVICU Prior to Anesthesia School	No	10	76.9
	Yes	3	23.1

Table 2. Percentage of Correct Responses for Each Pre-Test and Post-Test Question		
	Pre-Test Percent Correct (%)	Post-Test Percent Correct (%)
Question 1	69.2	61.5
Question 2	61.5	69.2
Question 3	30.8	84.6
Question 4	92.3	84.6
Question 5	53.8	76.9
Question 6	92.3	84.6
Question 7	30.8	76.9
Question 8	61.5	61.5
Question 9	38.5	30.8
Question 10	15.4	15.4

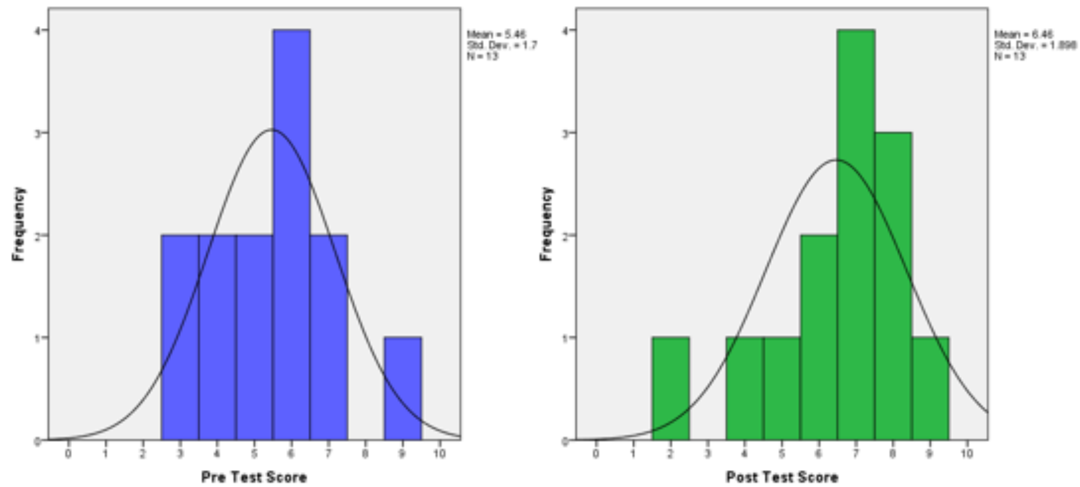

Figure 1. Distribution of pre-test and post-test scores

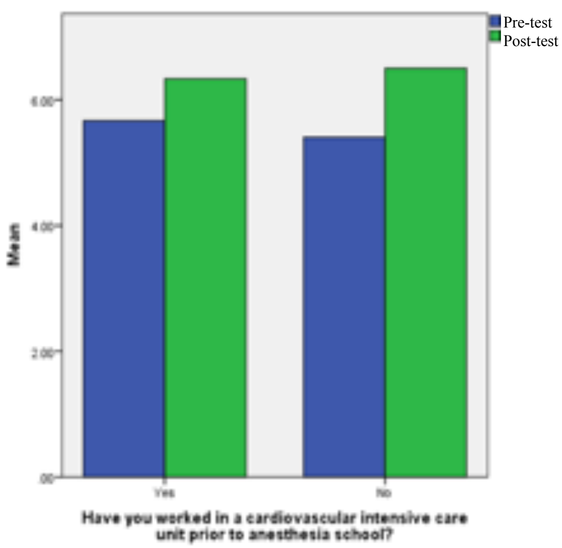

Figure 2. Difference in mean pre- and post-test scores based on whether respondents previously worked in a CVICU prior to anesthesia school

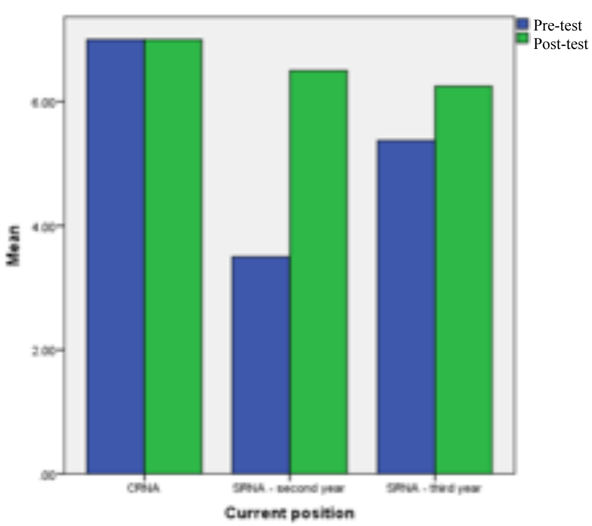

Figure 3. Difference in mean pre- and post-test scores based on whether respondents provided anesthesia in a cardiovascular setting

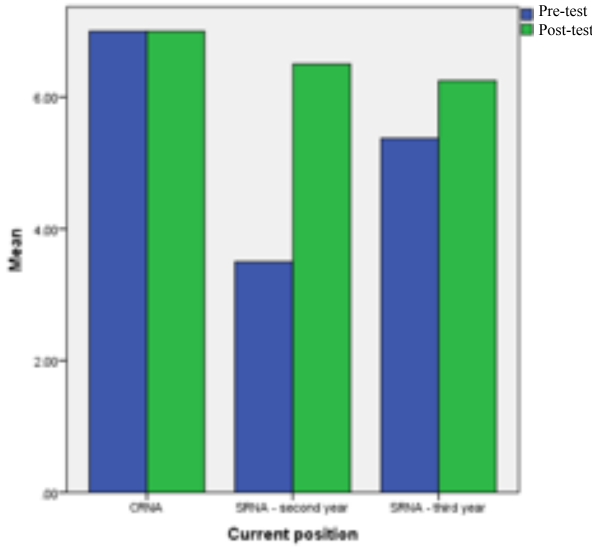

Figure 4. Difference in mean pre- and post-test scores based on respondents' current position

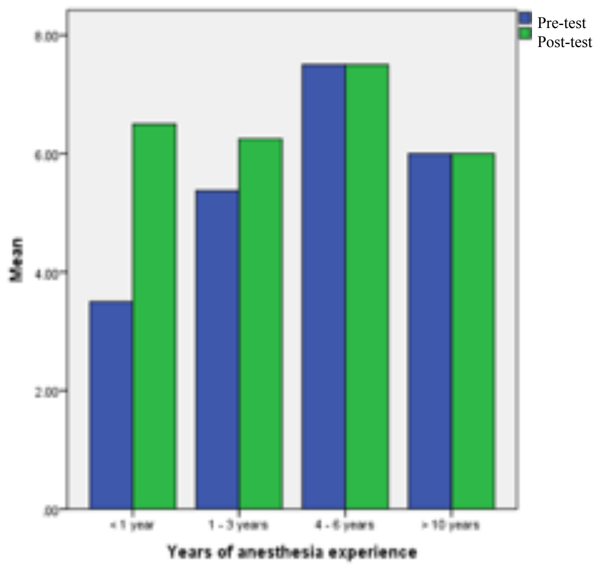

Figure 5. Difference in mean pre- and post-test scores based on respondents' years of anesthesia experience

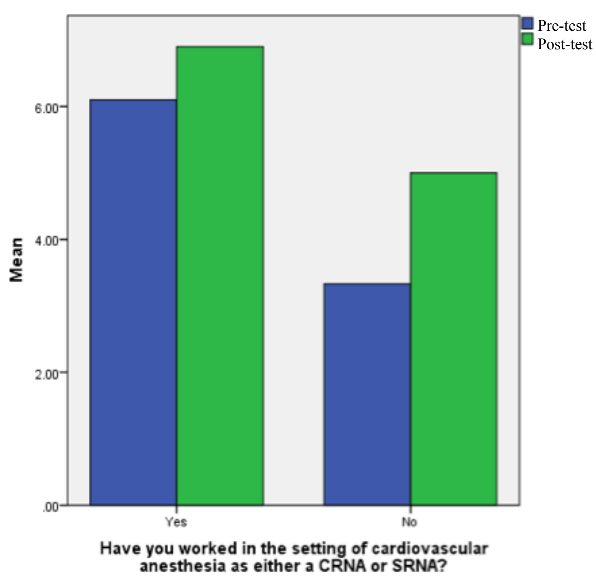

Figure 6. Difference in mean pre- and post-test scores based on respondents' age range