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Efficacy of a Mixed Methods Training Program for Transthoracic Echocardiography

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DNP Project

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Abstract

Background and Review of Literature: Currently, there is a knowledge gap in CRNA education. As anesthesia providers, CRNAs are licensed to perform cardiac diagnostic imaging such as TTE during surgery, yet it is often missing from CRNA school curriculum. Other studies have shown that simulation is an effective way of teaching this crucial skill.

Purpose: The project's goal was to establish the efficacy of using a mixed model computerized and in-person simulation program for training CRNAs in the use of TTE during non-cardiac surgery.

Methods: A training program was created that uses a computerized training session along with a hands-on simulation. This program focuses on ultrasound basics, landmark identification, and diagnosis of hypovolemia and ventricular dysfunction. A cohort of CRNA participants engaged in the training to study its efficacy.

Implementation Plan/Procedure: A pretest and posttest that included an attitudes survey was given to the participants to evaluate increases in competency and comfort in performing TTE skills as a result of the training program. A skills checkoff was also completed to demonstrate competency.

Implications/Conclusion: Data analysis suggests that the program was effective in increasing TTE knowledge and creating a base level of skill and competency in the use of TTE for all participants.

Keywords: TTE, transesophageal echocardiography, CRNA, nurse anesthetist, hypotension

DNP Project

Nurses have been administering anesthesia for over 150 years, and currently certified registered nurse anesthetists (CRNAs) represent about half of the anesthesia professionals currently licensed in the United States (Kapur, 2020). Nurse anesthetists function as part of an anesthesia care team or as independent providers, but there are knowledge and practice gaps that currently exist in some clinical areas. The use of perioperative ultrasound is within the nurse anesthetist's scope of practice as an advanced practice registered nurse (APRN), yet it is a skill that is often underutilized by practicing CRNAs. This Doctor of Nursing Practice (DNP) project is focused on bridging this knowledge gap and assessing the efficacy of a novel cardiac ultrasound training module.

Background

Nurse anesthetists are trained to provide all levels of anesthesia care, and can work in a variety of settings including urban teaching centers, critical access hospitals, and ambulatory surgery centers (APRN Consensus Work Group & NCSBN APRN Advisory Committee, 2008). The Institute of Medicine's position on APRNs is that they should be practicing to the full extent of their licensure and training (Institute of Medicine et al., 2016), but their licensure and training are not always compatible. With the current educational requirements, CRNAs may be licensed to provide services for which they have not had adequate training.

It is imperative that this knowledge gap in education and training be addressed. According to the APRN Consensus Model, "the education, accreditation, certification, and licensure of APRNs need to be effectively aligned in order to continue to ensure patient safety while expanding patient access" (APRN Consensus Work Group & NCSBN APRN Advisory Committee, 2008, pg. 5). It is well-documented that some CRNAs struggle in finding opportunities to perform regional blocks and therefore have fewer opportunities to develop the accompanying ultrasound skills (Wiggins et al., 2018), but other ultrasound skills are also lacking from CRNA practice as they are not required to be included in CRNA education but merely encouraged to be added to nurse anesthesia curriculum (American Association of Nurse Anesthetists, 2020; Lukyanova et al., 2021). The use of cardiac ultrasound technology, and specifically transthoracic echocardiography (TTE), is an evolving field in the perioperative environment, and includes applications such as assessing ejection fraction, hypovolemia, air embolism, valvular disease, and ventricular failure (Jasudavisius et al., 2015), which can all lead to unexplained hypotension and hypoxia in the operating room. Echocardiography involves the use of an ultrasound device that emits sound waves which bounce off structures in the body and return to the probe. The ultrasound machine then interprets these returning sound waves to visualize cardiac and surrounding structures and produces an ultrasound picture for the provider to view on the screen. Transthoracic echocardiography indicates that the ultrasound probe is placed on the patient's chest (Phoenix Heart Center, 2020).

When perioperative hypotension and general instability present, time is crucial. When anesthesia providers are faced with a critical drop in blood pressure, they have only minutes to identify and correct the cause before the patient's risk increases, and the longer it takes to diagnose, the greater the risk. Traditionally, CRNAs are taught to look at a variety of patient indicators to determine the cause of instability and then proceed to treatment. Cardiac ultrasound is a useful tool, when clinically indicated, to decrease the time to restoring hemodynamic parameters and/or to offer a more definitive diagnosis. Hypotension during non-cardiac surgery has an exposure-response relationship with increased morbidity and mortality up to thirty days postoperatively (Monk et al., 2015). The lower blood pressure drops, the shorter amount of time the patient is able to tolerate that pressure without suffering further complications. Despite the increasing applicability of the technology, there is no standardization or even a requirement of cardiac ultrasound education within CRNA programs (Lukyanova et al., 2021).

Problem Statement

An educational gap exists in the training of CRNAs in the use of transthoracic cardiac ultrasound technology (TTE) for the timely diagnosis of hypotensive etiologies and clinical instability, inhibiting the ability of CRNAs to practice to the full extent of their licensure and increasing the risk of negative patient outcomes.

The components of the PICOT (problem, intervention, comparison, outcome, time) question are aimed at assessing the efficacy of a novel cardiac ultrasound training session. The cardiac ultrasound training was developed by the project team and utilizes a blended learning style, with didactic and hands-on simulation portions to improve knowledge, skills, and attitudes (KSA).

Organizational "Gap" Analysis of Project Site

Overall, the hospital site offers numerous strengths and opportunities when combined with the project. The hospital offers an abundance of equipment and expert resources, as well as the technical and leadership support necessary for a successful evidence-based practice (EBP) project. Identified threats and weaknesses were overcome by strategic planning, which only adds to the numerous advantages that exist within the institution. These strengths and easily overcome weaknesses indicate that the pairing of the selected DNP project with the organization represents an opportune match.

PICOT Question

For current CRNAs working on the south campus of Barnes-Jewish Hospital (BJH) (P), will the completion of a blended approach, novel cardiac ultrasound training session (I), compared to standard education (C), increase knowledge, skills, and attitude for the use of TTE in managing perioperative complications (O) immediately after and for two months post program completion (T)?

Significance

The American Association of Nurse Anesthetists (AANA) has stated that point-of-care ultrasound skills are critical tools for CRNAs to utilize in practice, but also concedes that continuing education and professional development are necessary for CRNAs to become proficient in these skills (Lukyanova et al., 2021). If a patient's blood pressure drops to a mean arterial pressure (MAP) of less than 50 mmHg for even five minutes, that patient has a 2.4-fold risk of death in the next thirty days (Monk et al., 2015). Globally, over one million deaths and over seven million complications are experienced after general anesthesia (Debas et al., 2015), and perioperative hypotension is one of the most common factors found in anesthesia-related deaths (Lonjaret et al., 2014). Hypovolemia is a common complication perioperatively that causes hypotension. This occurs because all of the volatile inhaled anesthetics cause systemic vasodilation and extravascular fluid accumulation, patients are restricted in their fluid intake in the hours leading up to surgery, and there is a loss of sympathetic tone is a side-effect of many anesthetic medications and regional anesthesia (Joshi, 2020). All of these factors are present even under ordinary and optimal conditions. Ventricular failure is another cause of hypotension that must be distinguished from hypovolemia in order for treatment to be effective. Perioperative myocardial infarctions occur in 3% of non-cardiac surgeries and can lead to a hypokinetic ventricle that struggles to maintain adequate cardiac output (Sellers et al., 2018). If the patient is euvolemic or hypervolemic and a fluid bolus is given to correct the hypotension, the patient may suffer from fluid overload and overwhelm their already struggling heart. In this instance, the anesthesia provider can do a quick survey of the inferior vena cava to determine fluid status and check for hypokinetic ventricles by using TTE. By adopting TTE into their routine clinical practice, CRNAs will be able to decrease time to diagnosis, increase diagnostic accuracy, and decrease potential patient harm.

Review of the Literature

A literature review was performed by searching several databases for articles pertaining to cardiac ultrasound use in the operating room for troubleshooting hypotension and assessments of ultrasound training programs for anesthesia providers. Databases searched included PubMed (www.pubmed.ncbi.nlm.nih.gov), CINAHL (web.b.ebscohost.com), and MEDLINE (web.b.eschohost.com). Keywords used included anesthesia, CRNA, ultrasound, TTE, training, module, and similar renditions of these words. When searching for ultrasound training modules related to anesthesia, Medline returned the most articles (45), seventeen ultimately included. The CINAHL database had fewer articles returned with the same search terms and only generated twenty-one results, but they were more relevant. Eleven of these articles were included. PubMed was searched using the same general terms and yielded similar results with many of the same articles as the previous two databases, and added twenty-one articles to the count after removing duplicates from the search.

Several medical subject heading (MeSH) terms were also used to search PubMed and included anesthesiology, echocardiography, hypotension, and perioperative. One MeSH search using anesthesiology returned a much higher article count than using perioperative in its place; it seems as if perioperative is implied when anesthesia is involved. These searches added another six articles to the count. The time limit set for all article searches was set at ten years, except the Medline and PubMed searches that returned the highest number of articles which used five years to narrow down the options. At the end of the search, fifty-five articles were found to be suitable for the literature review on the chosen topic and represent a wide range of evidence types, levels, and qualities. Studies were assessed based on the Johns Hopkins Nursing Evidence-Based Practice Evidence Level and Quality Guide (John Hopkins, n.d.). Only high- and good-quality studies were further reviewed and the list was narrowed to seven studies, a set of practice guidelines, a systematic review, and a literature review.

Two types of articles were included in the final count. The first group focused on perioperative hypotension and the use of cardiac ultrasound for investigating the root cause of low blood pressure. Inclusion criteria were recent studies, preferably in the last five years but up to ten years for high quality studies, adult population, perioperative hypotension defined as low blood pressure occurring in the operating room, and the use of cardiac ultrasonography which includes either transesophageal echocardiography (TEE) or transthoracic echocardiography (TTE). The second group of studies involved the development, implementation, or assessment of ultrasound training methods for anesthesia providers. Populations that included either certified registered nurse anesthetists (CRNAs), physician residents, or physician fellows were selected. Studies were not excluded for teaching other methods of ultrasound, such as regional ultrasound techniques, in order to gain a broader understanding of the different teaching methodologies that may be used in this setting.

The largest portion of studies focused on the evaluation of training methods for cardiac ultrasound. Four studies found that simulation-based learning strategies, either as the focus or as an adjunct, were useful for increasing trainee proficiency and skill in using ultrasound to identify specified landmarks and increased ultrasound knowledge (Shields & Gentry, 2020; Ramsingh et al., 2015; Wiggins et al., 2018; Chenkin et al., 2019). These were all good- or high-quality quasi-experimental studies, with one exception. The study by Shields & Gentry (2020) was a randomized control trial that provides evidence that simulation-based training is superior to solely web-based. Yamamoto et al. (2018) also assessed the efficacy of a simulation adjunct training session. They focused on the time period following the training to determine when skills and knowledge gained from the training begin to deteriorate. Their study was a high quality, quasi-experimental study that quantified the degree of decline at one- and three-month intervals post-training. Their findings suggest that continued use of the acquired skills or further follow-up training is needed to maintain competency of ultrasound skills.

The other two studies addressed the use of cardiac ultrasound for hypotension management by anesthesia professionals. In a high-quality, quasi-experimental study, Kratz et al. (2017) gave quantitative and qualitative properties of the effects of TTE on intraoperative management of hypotensive episodes. This study is crucial to include because it supports cardiac ultrasound technology's usefulness for the management of hypotension in the operating room, as evidenced by a change in management in 66% of the study cases (Kratz et al., 2017). This was also the only study that included confidence intervals in the calculations, which increases reliability and precision. The other article examined the predictive value of velocity time integral (VTI) measurements obtained through TTE in determining which patients are at higher risk for hypotension after spinal anesthesia.

The remaining three articles were chosen due to their support of using cardiac ultrasound for managing hypotension intraoperatively. The American Society of Anesthesiologists (ASA) is the professional association for physician anesthesiologists in the United States and is one of the national authorities on anesthesia care in the United States. They have specifically developed guidelines for the use of TEE in the operating room and fully support the use of TEE for non-cardiac cases for multiple reasons including the management of hypotension during surgery (ASA, 2010). Articles two and three are a literature and a systematic review of TEE use in non-cardiac surgery by anesthesia providers and both offer good- or high-quality support of the intended project (Fayad & Schillcutt, 2018; Jasudasivius et al., 2016).

After reviewing all of the pertinent articles, there is ample literature to support the proposed PICOT project. Despite COVID-19 restrictions, it is evident that the PICOT project should include a simulation component, as this has been shown to have good learning outcomes (Shields & Gentry, 2020; Ramsingh et al., 2015; Wiggins et al., 2018; Chenkin et al., 2019). Overall, the evidence strength of the literature review is high, with most of the studies being level I or II on the John Hopkins scale (John Hopkins, n.d.) and all being of acceptable quality. The biggest weaknesses extend from the lack of reliability, precision, and accuracy measures given by the articles. Regardless, the overall quality of the evidence is more than adequate to support the proposed PICOT project in assessing the efficacy of a cardiac ultrasound training session.

Evidence Based Practice: Verification of Chosen Option

Based on the preceding literature review, the chosen intervention of using a hybrid computerized and in-person simulation model for increasing CRNA knowledge and skill in performing diagnostic TTE was selected.

Theoretical Framework

The change project is focused on addressing an educational and practice gap. Theoretical and conceptual frameworks for DNP projects may come from outside the specialty of nursing, so considering that the aspects of the project include a change project in education, the KSA framework was chosen (Townsell, 2013). The KSA model stands for knowledge, skills, and attitudes and is the framework chosen to represent the educational efficacy of the designed program. Knowledge was assessed in a pre/post-test format using computerized questionnaires that are identical in questions but in a randomized order. Increased skills were measured by having participants do a skills checkoff by identifying landmarks and correctly diagnosing hypotensive etiologies. Attitudes towards the importance of the skills and likelihood of adopting them into practice were also assessed electronically at the conclusion of the educational session.

Goals, Objectives, and Expected Outcomes

The goals of this project are focused on identifying baseline knowledge, providing a hybrid training program on the use of TTE for managing hypotension in the operating room, and evaluating the knowledge increase assessed as a result of the training, as well as the general attitudes toward TTE use and training in non-cardiac settings (Appendix A). The first goal, identifying baseline knowledge, was done through the demographic questionnaire as well as the pretest that was sent prior to the recorded training module. It was expected that there would be very little baseline knowledge of TTE, as well as infrequent use in daily practice among the participants. For the next goal, providing a hybrid training program, a multi-step approach was used to disseminate the information via email and an in-person training simulation. After the training, knowledge and skills were assessed to quantify the degree of learning that occurred as a result of the learning modules. Expected outcomes are an increase in the amount of knowledge and demonstrable skills of participants as evidenced by a posttest and in-person skills checkoff. Finally, the attitudes of CRNAs towards TTE training and usefulness in non-cardiac settings were assessed through an attitudes assessment that was emailed to participants after the conclusion of the training. It was anticipated that CRNAs will have a positive view of TTE training in general, the specific training module offered, and the applicability of the training to their future practice.

Project Design

When designing an EBP project or research study, the first step is to recruit an interprofessional team that will be tackling the project together (Dang & Dearholt, 2018). During investigation of pertinent clinical issues for potential projects, a current project at Barnes-Jewish Hospital was identified as a candidate project. This was then determined to be the target DNP project. Pre-existing interest by a CRNA and anesthesiologist provided a jumpstart on team recruitment. Both members of the team functioned as consultants for the project, as well as having collaborative engagement involving development of the training module.

Additional stakeholders for the proposed project exist, but the list can be quite extensive given that a stakeholder is anyone who has a personal or professional interest in the project (Dang & Dearholt, 2018). The most important stakeholders identified include those that needed to be informed at certain intervals in the process and/or needed to give approval in order to advance the project. Examples include the course instructor for Promoting EBP I, II, III, and IV, the program director, and the chief CRNA at the hospital. Patients are also a critical stakeholder, as the goal is to improve patient care by increasing CRNA skill and utilization of cardiac ultrasound which is projected to have a positive impact on patient outcomes by reducing misdiagnoses and time spent in a hypotensive state.

Project Site and Population

Once stakeholders were identified, it was imperative to evaluate the feasibility of a proposed project before proceeding to prepare for the project approval process. A strengths, weaknesses, opportunities, and threats (SWOT) analysis represents a framework that can be used to identify the key strengths, weaknesses, opportunities, and threats. Strengths and weaknesses in the SWOT analysis are related to the organization, and thus determine how well the project and organization are matched (Wijngaarden et al., 2012).

The organization involved in the DNP project is a large, academic teaching hospital with ample resources and anesthesia experts which has aided in all phases of the project development and analysis. The physical resources that were necessary for project completion included appropriate ultrasound technology that is in good working condition and up-to-date, as well as simulation facilities that can be utilized for staff training. Just as important as the technology and equipment is the availability of anesthesia experts to assist in development of the training modules and consult on the research details. Both of these requirements are met by the hospital and affiliated organizations on the same campus. The training module project already underway at BJH involves two anesthesia providers that have proven to be invaluable to the research conducted, and one specifically has experience in using ultrasound training as a DNP project. There is also a high level of support from nursing as well as medical staff for continuing CRNA education and empowering them to incorporate advanced techniques in their practice.

Weaknesses of the project are much smaller in number, but still represent hurdles that needed to be addressed. Equipment needed for TTE was not always readily accessible. It was hypothesized that anesthesia staff outside of cardiothoracic and vascular areas may be more hesitant to adopt cardiac ultrasound in their practice or even participate in training if they do not see the value in cardiac ultrasound for non-cardiac cases. The largest weakness occurred in the face of the current pandemic, with COVID restrictions playing a role in limiting the amount of face-to-face contact. These weaknesses were addressed by ensuring access to TTE equipment for training, educating CRNAs on the benefits of cardiac ultrasound for problem management, and designing the project to adhere to COVID restrictions without jeopardizing the integrity of the project.

Opportunities and threats involve influences from within the organization in addition to ones from outside the organization (Wijngaarden et al., 2012). For the project, opportunities that were identified involved cost-effectiveness and staff experience. Due to the nature of the project, the costs associated with the research and analysis were minimal and were further minimized by using virtual assessments for measurement of learning in the participants. The project also offers a low cost and minimally invasive solution to trouble shooting during operative cases, which should increase stakeholder support from within the organization. Several threats to the project involve time constraints. The original project belongs to staff members and not the student researcher, which had the potential to lead to problems in maintaining the deadlines needed for the student research project. Since it involves a training program, it also increased the time burden of the project since modules needed to be created before being distributed to CRNAs. These threats were managed by making the timetable clear to the entire team from the beginning of the project, and by team members keeping each other informed of progress and pitfalls on the way.

The population for the project consisted of CRNAs working in the south campus and Parkview Tower operating rooms at Barnes-Jewish Hospital. The only inclusion criteria listed was any CRNA who regularly works in the aforementioned locations. Exclusion criteria were as follows: CRNAs who only work per diem, and CRNAs who are predominantly stationed in the north campus operating rooms. Participant recruitment included emailing a flier to eligible CRNAs.

Methods

Implementation of the project occurred by creating a training module and in-person training session, distributing the educational materials and hosting the training session, gathering data, and subsequently analyzing the data. This was the first PDSA cycle for implementation of the training program, should the project site choose to continue after completion of this project.

Measurement Instruments

In order to measure the outcomes of this DNP Project the following instruments were used: pre-test questionnaire (Appendix B), post-test questionnaire (Appendix C), skills check-off list (Appendix D), and attitudes survey (Appendix E). No suitable measurement tools were found during a search of the literature, leading the researcher to develop the measurements and have them reviewed by the experts on the project team to establish validity. Development of the measurement tools included review of pertinent research studies, which all indicated development of their own tools by the research team. This led to the decision to create unique tools for this project. Goals were set for the data type that will need to be extracted and then questions were designed to elicit the desired information. The resultant measurement tools were then sent to three TTE experts: the practicing CRNAs and anesthesiologist on the research team.

Demographic variables were measured on the pre-test and include age, gender, race, amount of time spent as a practicing CRNA, and amount of time employed at Barnes-Jewish Hospital. These questions were formatted as multiple choice, with gender and race having an “other” option that allows participants to free-text their response. The pre-test questionnaire also contains fifteen multiple-choice questions involving TTE images, how to find views, identification of landmarks, and diagnosis of problems. This allowed a score to be calculated that represents the pre-intervention knowledge level of TTE. The post-test contains the same knowledge questions as the pre-test but omits the demographic questions. The post-test was administered immediately after the training session as well as one and two months later, which was then used to calculate the increase in knowledge and the subsequent sustainability of the results. The skills check-off list contains five views for the participants to obtain and subsequent landmarks to be identified in each view, as well as four pathologies for participants to identify. This data represents the dependent variable of ultrasound proficiency. The last dependent variable is the attitude score for each participant, which was measured by the attitude survey using a Likert-type scale. This survey contains eight questions inquiring about the CRNAs' perception of the importance of TTE use for non-cardiac surgery and the usefulness of the training program.

Data Collection Procedure

The EBP implementation strategy that was used for this project is the Model for Improvement and the Plan, Do, Study, Act (PDSA) Cycle (Institute for Healthcare Improvement, n.d.). The Model for Improvement seeks to answer three questions: what is the goal, how will accomplishment of the goal be defined, and what change can be made to reach the goal? Once those questions are answered, a PDSA cycle is initiated, which in the case of this project, will include pre-intervention planning and setup, the intervention with data collection, and post-intervention analysis and study.

The first step in the project was to complete the internal review board (IRB) approval process, and then move on to module development. The project team members, as TTE experts, played a major role in development of the training program. A computerized educational module was created by using Microsoft PowerPoint software and recording a voice over lecture of the different views, anatomical landmarks, and diagnostic criteria. An outline was created for the in-person training session that details the same topics. Soon after IRB approval was achieved, participant selection began by sending an email to all CRNAs to recruit interested participants with a deadline given of 1-2 weeks to respond. The goal was to recruit twenty-five CRNAs for study participation. Live model recruitment also occurred at this time, by sending out a flier through email to undergraduate nursing students at Barnes-Jewish College. A volunteer could be any student who is able to meet the necessary time requirements. Once the deadline was reached, the participants were contacted by email with details about the study including a projected timeline and a consent information sheet, again with a deadline of about one week. When responses are received, the pre-test was sent via email with a Qualtrics link, the PowerPoint modules were attached to the email, and participants were assigned a date for the in-person skills session.

There were two skills sessions to keep the groups small for optimal learning. These sessions included a TTE demonstration, as well as hands-on simulation and live model practice. Once the sessions were completed, another Qualtrics link was sent with the initial post-test and attitudes survey. This same survey was sent again at the one- and two-month post-session marks, each time with a deadline of one week to complete the survey. For each data collection period, the student researcher used Microsoft Excel to input or export all data.

Cultural considerations have been made in the development of the measurement tools to allow for cultural sensitivity with data collection. Gender and racial demographic data include an “other” option to allow for non-binary, mixed racial, and any other unique response types to these questions. Language barriers are not anticipated due to the participant pool only including CRNAs that currently work at Barnes-Jewish Hospital, indicating that they are at least conversationally proficient in English. It is not anticipated that cultural composition will influence the data collected.

Cost-Benefit Analysis

The costs associated with this project consisted mainly of software expenses and miscellaneous costs (Appendix F). The proposed budget accounts for the team members' time, as well as the CRNAs who participated in the training program, though these salaries did not need to be paid directly by the research project. Software expenses include those incurred in the use of SPSS statistics, Microsoft Office programs, and Qualtrics. Miscellaneous office supplies and printing have also been included in the estimate. The potential benefit for the clinical site, Barnes-Jewish Hospital, is the training that the CRNA staff will receive. There is also a potential benefit of fewer complications for future patients if hypotensive episodes are able to be efficiently diagnosed with the use of TTE by the CRNAs. Some resources were able to be used without cost to the project, such as the TTE simulation mannequin and facility that is provided by Barnes-Jewish College and the Washington University School of Medicine's Department of Anesthesiology.

Timeline

The project began with IRB approval, which was received in September (See Appendix G). While waiting for approval, module development was in process, and then participant selection occurred. Next, the initial demographic survey and pretest were sent out. The recorded lectures were then emailed to the CRNAs to view at their own leisure prior to the scheduled training sessions. The in-person simulations occurred on Wednesday mornings during the protected conference time. Once the modules were completed, the assessments occurred. The skills checkoffs were completed over the next few weeks. After checkoff completion, posttests and attitudes surveys were sent out to participants immediately and at the one- and two-month periods post intervention.

Ethical Considerations/Protection of Human Subjects

The Barnes-Jewish College Goldfarb School of Nursing Internal Review Board (IRB) and Washington University IRB approval was obtained prior to initiating the DNP Project. The researchers ensured that the Health Insurance Portability and Accountability Act of 1996 (HIPAA) was strictly followed in order to maintain the privacy of all participants, and they also followed the *Standards of Care* in ensuring participants are protected. Information collected as part of this research project was voluntarily given by participants and did not include any identifying information. The project is a measure of the educational value of the developed program and does not include any intervention other than the computerized modules and in-person simulation, and therefore does not pose any risk to the participants. Surveys were either coded with identification numbers that are known only to the research team and kept under password protection, or they were submitted anonymously.

Data Analysis

The data collected from the completed surveys includes three distinct data sets representing the knowledge, skills, and attitudes of the participants in relation to TTE, as well as demographic data of the participants. Demographic data was analyzed using descriptive statistics. Data representing knowledge was collected in the form of pre- and post-test scores, which were compared using paired t-tests to check for significance, with $p<0.01$ indicating statistically significant differences. Data collection for the skills portion simply calculated the pass/fail rate of the cohort for the in-person skills check-off, and did not require statistical analysis due to only including a single data point. Participant attitudes towards TTE and the training program were converted into frequency tables and then analyzed using a Chi-squared test to compare change of distribution between time points for each of the eight questions, and the significance level was set to 0.05.

Demographics

Demographic data for the participants included age, gender, race, years of CRNA experience, years employed as a CRNA at BJH, and highest degree obtained (Table 1). While gender was evenly distributed throughout the group, with 50% of participants being female and 50% male, the other variables were heavily skewed in one direction. While the ages of the participants ranged from 20s to 50s, 80% indicated that they are in their 20s and 30s. One-hundred percent of participants also identify as white/Caucasian. Most of the participants are newer CRNAs, with 70% indicating they have three or fewer years of experience, both as a CRNA and as practitioners at BJH. The majority of participants also hold Masters degrees, with the remaining 20% indicating they have obtained either a Doctor of Nursing Practice or Doctor of Nurse Anesthesia Practice.

Knowledge

The test that was administered to the participants consisted of 15 multiple choice questions, but after administration of the tests, one question was thrown out due to not having a clear correct answer. The tests were all given a score out of 14, and the mean, standard deviation, median, minimum, and maximum were calculated for each set of tests (Table 2). The pre-test had a mean score of 56.3% (sd=0.052, min=0.50, max=0.64). The initial post-test score increased significantly to a mean of 92.2% (sd=0.042, min=0.86, max=1.00) with $p<0.0001$. Post-test 2 and 3, administered at one- and two-months post-intervention, also had significantly increased mean scores of 84.5% and 84.1% compared to the pre-test with $p<0.0009$ and $p<0.0004$, respectively. Post-test 2 and 3 were then compared to post-test 1 to establish the degree of sustainability. These comparisons show no statistical difference between post-test 1 scores/post-test 2 scores (p=0.1212) and post-test 1 scores/post-test 3 scores (p=0.1522), indicating that the increase in scores was sustainable over the next two months.

Skills

To evaluate the skills of the participants, a skills check-off was conducted after completion of the modules and practice session. Each participant was given five TTE views with landmarks to identify for each view. The mannequin was then switched to simulate four pathological states for the participants to individually diagnose. There were a total of 34 views, landmarks, and pathologies to identify, and participants were given a score of "pass" if they had five or fewer mistakes. Out of the ten participants, 100% passed on the first attempt, indicating that each was proficient in TTE use and diagnostics at the time of program completion.

Attitudes

Attitudes towards TTE, including its usefulness and participant confidence in using TTE, were evaluated using seven questions with responses on a Likert-type scale (Table 3). The first statement on the survey read "using TTE during non-cardiac surgery is useful for intraoperative decision making", with 94.6% of the responses from all four time periods indicating they somewhat or strongly agree. There was no statistical difference between the time periods (p=0.132) with a Friedmans test. Participants also mostly disagreed with the statement "the usefulness of TTE is mostly limited to cardiac surgery, with 85.7% of the responses from all four time periods being strongly or somewhat disagree. The Friedmans test also indicated no statistical difference between the time periods (p=0.775).

The next two survey questions addressed interest in continuing TTE education and implementation into practice. When presented with the statement “I will implement in the future, or have implemented, non-cardiac TTE into my practice”, 77.8% percent of the responses from all four time periods strongly or somewhat agreed. A Friedmans test was performed, and the responses did not differ significantly between survey periods ($p=0.183$). The next survey statement was “I would like to continue to learn about the use of TTE for troubleshooting during surgery”, with 96.3% of responses from all four time periods indicating they strongly or somewhat agreed. Friedman's test indicated the responses were not statistically different between the survey periods ($p=0.141$).

Three questions assessed the participant’s comfort level in performing TTE. In response to the statement “I am comfortable with using TTE to diagnose hypovolemia”, the results changed significantly post-intervention when compared using a Friedmans test ($p<0.001$). Pre-intervention, only 30% of participants somewhat or strongly agreed with the statement. Immediately post-intervention, this went up to 100%, and remained elevated at 85.7% of participants at the two-month post intervention mark. Similarly, participants were presented with the statement “I am comfortable diagnosing reduced ventricular function with TTE”: only 20% strongly or somewhat agreed pre-intervention, which increased to 100% immediately post-intervention and 85.7% two months post-intervention. Friedmans test confirmed that these results were statistically significant ($p<0.001$). Twenty percent of participants somewhat or strongly agreed with the statement “I am comfortable choosing the correct probe for performing TTE” pre-intervention. Immediately post, the total was 100%, and two months later 71.4% of participants still somewhat or strongly agreed. Friedmans test indicated this was statistically significant ($p<0.001$).

The last question on the attitudes survey was only given immediately, one month, and two months post-intervention and asked participants to select their level of agreement with the statement “this course was successful in increasing my proficiency with TTE”. A total of 97.3% of the responses from the three time periods indicated the training program was successful, with no significant difference between the time periods when a Friedmans test was performed ($p<0.001$).

Evaluation and Outcomes

All of the objectives for this project were effectively met after data collection and analysis of the results. The knowledge pre- and post-tests established that the baseline knowledge of CRNAs regarding TTE is relatively low, as indicated by the mean score of 56.1%. This is not surprising, as TTE training is not a mandated part of CRNA education and continues to be an underutilized diagnostic tool in the perioperative setting. Despite the initial assumption that participants would have a range of years of experience as a CRNA, the volunteers had a tendency to be in the younger age brackets and the majority had been practicing as a CRNA for three years or less. This likely represents some degree of volunteer bias, as the department composition includes a wide range of years of experience.

After successful creation and distribution of the hybrid training module, the hypothesis that CRNA knowledge of TTE use would subsequently improve is supported by the statistically significant difference of the post-test scores when compared to the pre-test. In addition to the theoretical TTE knowledge, the participants were also able to demonstrate the clinical application of the content by passing the skills checkoff with a 100% pass rate. The multiple post-test data points suggests that while continuing education and practice is important to maintain TTE skills, the training program was effective in increasing these skills enough to be sustained throughout the initial months following program completion. Increases in the attitudes scores concerning comfort in TTE as a diagnostic tool also suggests that the confidence level of the CRNAs increased along with their skills. Attitudes towards TTE use during non-cardiac surgery were generally favorable and stable over the entire data collection period, suggesting the training module had no effect on these views.

Limitations

The positive results for this study do have some limitations that warrant discussion, as they impact the ability to generalize the findings to a larger population. This project had a small sample size and was limited to practitioners at a single institution within predetermined surgical locations. Future projects may consider broadening the pool of participants to a multi-center trial in order to increase the sample size as well as gain insight into the program's effectiveness on a larger scale in a variety of settings. The project was also not randomized and did not include a control group, so the positive findings support the success of the hybrid teaching method but do not compare its effectiveness to other instructional strategies. Further efforts to develop validation data for the developed data collection tools beyond expert review would also increase the strength of the evidence. Several mistakes on the knowledge question portion were not identified until after data collection was complete, resulting in two questions having two correct answers and one question being thrown out due to not having a clear correct answer. These questions were scored consistently between the pre- and post-tests to minimize any impact to the results. The last limitation involves sustainability, as the skills check-off was not completed over multiple time periods. Though participants indicated they sustained high levels of comfort in performing their skills over the next two months, this could not be corroborated by passing a subsequent check-off since the project only included the check-off at one time period.

Strengths

Several strengths of the project have been identified. The overall cost-effectiveness of the project is high, with the majority of costs being the time devoted by the expert project members. There is also a direct benefit to the institution hosting the project in the form of clinical education for employed CRNAs. While further editing of the data collection tools is needed, the groundwork has been completed which will lead to faster and easier implementation of future versions of the project if there is desire to continue the TTE education endeavors. Despite the small sample size, the results are clearly in support of the program's effectiveness, as evidenced by the statistical analysis.

System and Practice Impact

The results of this project support the hypothesis that a mixed methods teaching model, with the use of simulation and hands-on practice incorporated, is an effective way to teach TTE to CRNAs in the clinical setting. As previously discussed, TTE skills are useful for improving patient outcomes and should be utilized to a higher degree than is currently standard in clinical practice. In order to increase TTE skills among CRNAs, it is recommended that the educational requirements for CRNA programs be expanded to include education on the use of bedside transthoracic ultrasound. The American Association of Nurse Anesthesiology supports the use of TTE and continued education aimed at increasing competence in this area (AANA, 2020), and they would be a great target of campaigns to support the standardization of TTE education into graduate CRNA programs. The decision, however, will be up to the Council on Accreditation of Nurse Anesthesia Educational Programs (COA), as they set the rules and guidelines for accreditation of CRNA programs in the United States and Puerto Rico, including curriculum and graduation requirements. Nursing leaders, especially in the field of anesthesia, should continue to advocate for the addition of TTE to curriculum requirements in order to support nurse anesthetists practicing to the full extent of their licensure as well as ensuring the highest quality of care for patients. In addition, these skills can be taught to current CRNAs through the use of workshops and in-house education to further support these goals.

Conclusion

In order to address the educational gap that exists within nurse anesthesia education, ongoing efforts to implement TTE training for current nurse anesthetists should be paired with nursing leadership efforts to make TTE a mandatory graduation requirement for future students. The results obtained from this project support the use of simulation and hand-on practice sessions as an effective teaching model that increases skills, competency, and confidence. To further support the validity of these findings, the project could be repeated in the future with some improvements to the project design, such as editing the data collection tools, adding additional skills check-offs, and having participants fill out surveys in-person at the completion of the check-offs to improve submission rates. The findings of this project will be distributed to the academic community through a formal presentation, a journal submission, and poster presentation in order to continue to support the endeavors of nurse leaders and educators in maximizing the quality care given by nurse anesthetists.

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Table 1

Demographic data of participants

Gender	**Number (n)**	**Percent (%)**
Male Female	5 5	50 50
Age Group	**Number (n)**	**Percent (%)**
20-29 30-39 40-49 50-59	4 4 1 1	40 40 10 10
Race	**Number (n)**	**Percent (%)**
White	10	100%
Years as CRNA	**Number (n)**	**Percent (%)**
0-3 4-6 7-10 11-20 20-30	7 0 1 1 1	70% 0% 10% 10% 10%
Highest Degree	**Number (n)**	**Percent (%)**
Masters Doctorate	8 2	80% 20%

Table 2

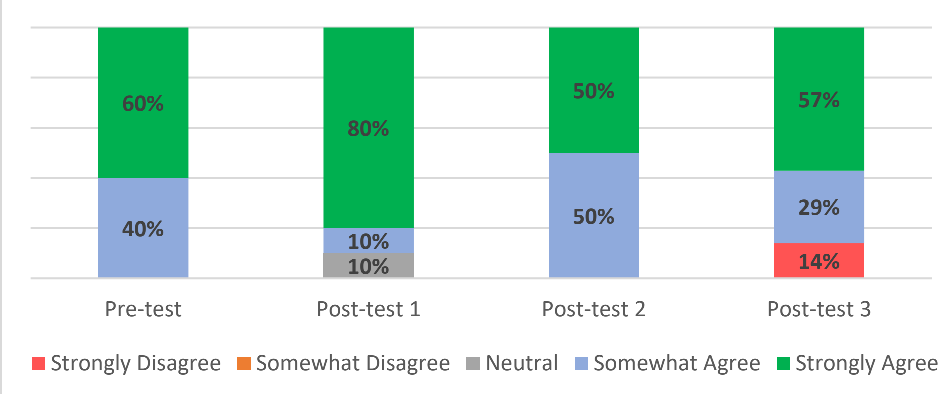
Knowledge - Pretest and posttest scores

	Pre-test	Post 1	Post 2	Post 3
Mean	56%	92%	85%	85%
Max	64%	100%	100%	93%
Min	50%	86%	64%	50%

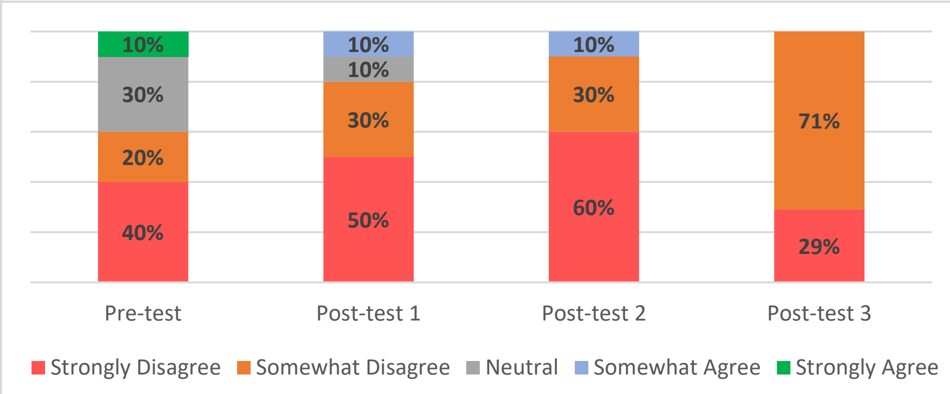
Table 3

Attitudes responses

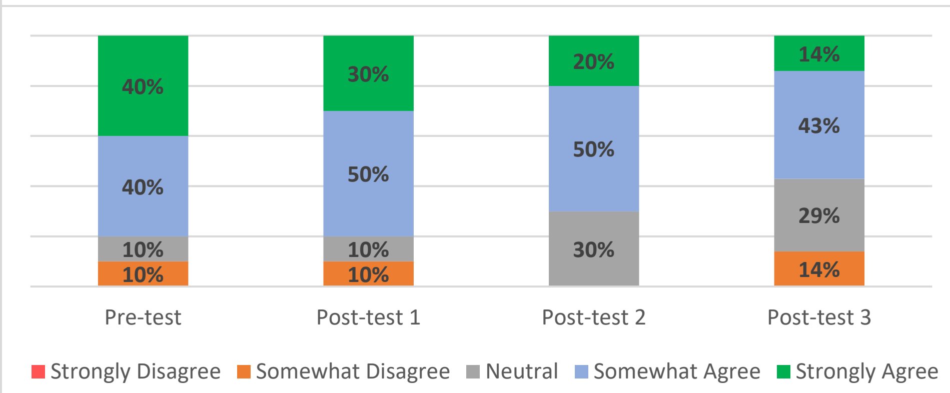
1. Using TTE during non-cardiac surgery is beneficial for intraoperative decision making



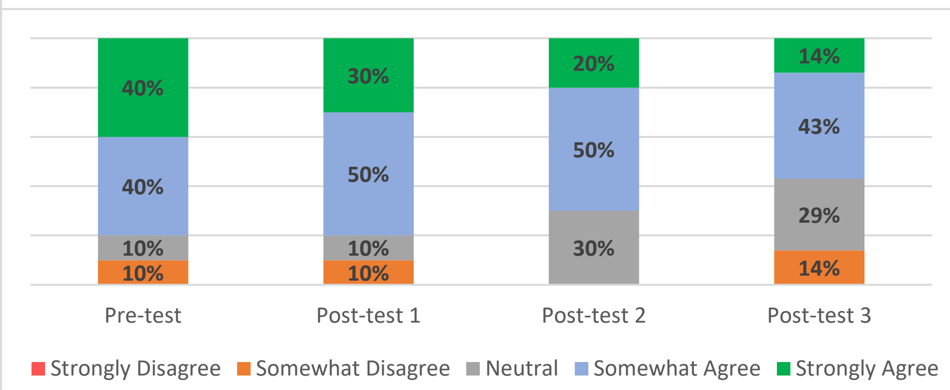
2. The usefulness of intraoperative TTE is mostly limited to cardiac surgery



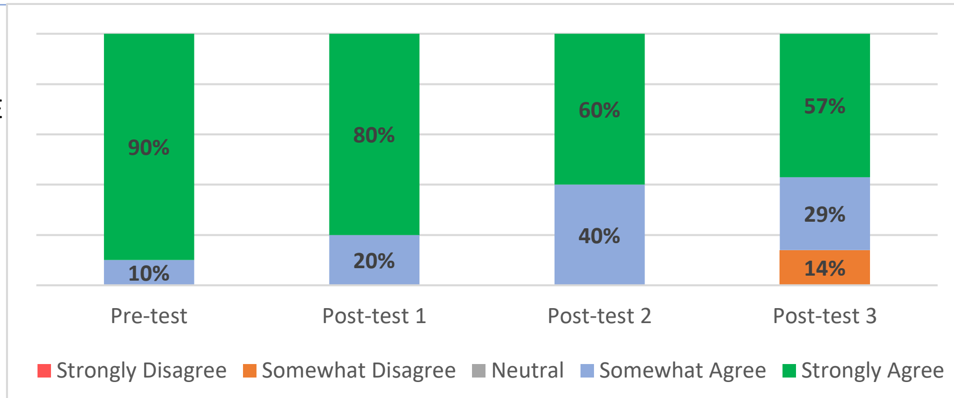
3. I will implement in the near future or have implemented non-cardiac TTE into my practice



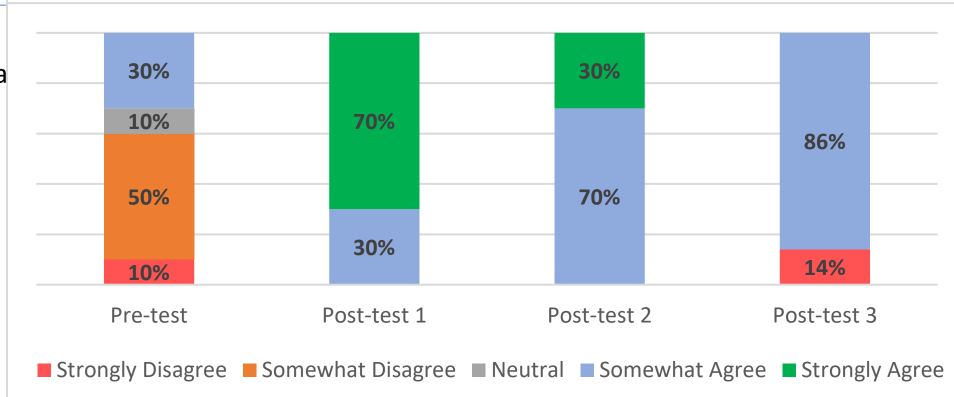
4. I would like to continue to learn about the use of TTE for troubleshooting during surgery



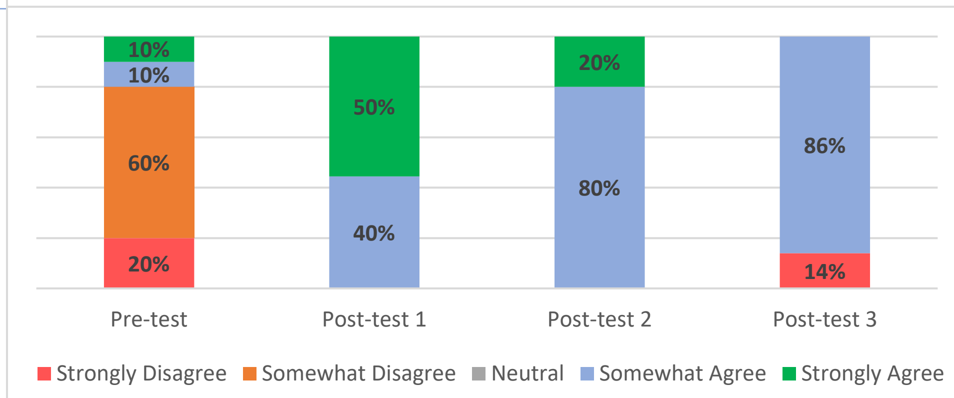
5. This course was successful in increasing my proficiency with TTE



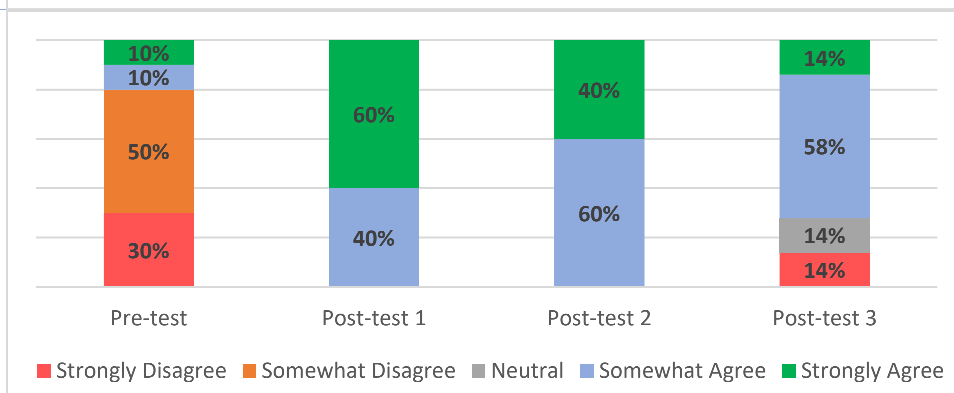
6. I am comfortable diagnosing hypovolemia with TTE



7. I am comfortable diagnosing reduced ventricular function with TTE



8. I am comfortable with selecting the right probe for performing bedside TTE



Appendix A

Goals, Objectives, and Expected Outcomes

Goal	Objective	Expected Outcome
Assess demographic data on the participants.	Demographic questions will be sent via email 1 week before the computerized module is released to all participants who were identified in previous steps. Demographic questions will include years of experience at BJH, years of experience as a CRNA, previous TTE training, and current use of TTE in non-cardiac clinical practice.	The CRNAs will have a range of years of experience, a low amount of previous TTE training, and low incidence of current use in clinical practice.
Provide a computerized training session to participants.	A 1-2 hour recorded module will be sent to participants through email at the end of October 2021, with a deadline of two weeks.	Participants will participate in learning activities aimed at increasing TTE knowledge.
Provide a hands-on training session to participants.	A 1-2-hour in-person simulation training will be held on a Wednesday morning in November 2021, two weeks after the recorded module is sent, from 0630 to 0830 to give CRNAs a chance to practice TTE techniques with feedback.	Participants will participate in learning activities that increase their ability to identify correct TTE views, landmarks, pathology, and anatomy.
Quantify the amount of baseline knowledge possessed by the CRNAs participating in the study.	A pretest will be administered by sending a Qualtrics link through email one week prior to the recorded module being released.	The CRNAs will increase their TTE knowledge and ability to identify correct TTE views, landmarks, anatomy, and pathology.
Quantify the increase in TTE knowledge seen after module completion.	A posttest will be administered by sending a Qualtrics link through email one week after the in-person simulation.	
Quantify the degree of TTE technical skill achieved by the CRNAs.	Individual skill checkoffs will occur on a Wednesday morning from 0630 to 0830 and the following Saturday morning from 0900 to 1100, one week after the training simulation.	Participants will be able to pass a skills-checkoff to correctly identify views, landmarks, anatomy, and pathology.
Determine the attitudes of participants towards TTE training in general, its importance and usefulness in clinical practice for non-cardiac surgeries, and CRNA expectancy of adopting these skills into their own practice.	A computerized attitudes assessment will be administered by sending a Qualtrics link to participants with the posttest by email.	Participants will have positive attitudes towards the use of TTE in everyday clinical practice and expect to implement these skills in their own practice.

Appendix B

Pre-test questionnaire

Demographic information:

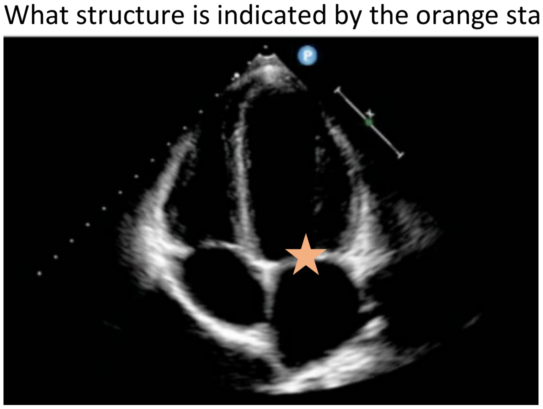
1. Age:
    a. 20-30
    b. 31-40
    c. 41-50
    d. 51-60
    e. Over 60
2. Gender
    a. Male
    b. Female
    c. Other: ___________________
3. Race
    a. White
    b. Black or African-American
    c. Hispanic origin
    d. Native American
    e. Asian or Pacific Islander
    f. Other: _________________________
4. Years as a CRNA
    a. 0-3
    b. 4-6
    c. 7-10
    d. 11-20
    e. 20-30
    f. More than 30
5. Years employed at BJH as a CRNA
    a. 0-3
    b. B4-6
    c. 7-10
    d. 11-20
    e. 20-30
    f. More than 30
6. Highest degree obtained
    a. Bachelors Degree
    b. Masters Degree
    c. DNP
    d. DNAP
    e. Other: ________________________

TTE Knowledge

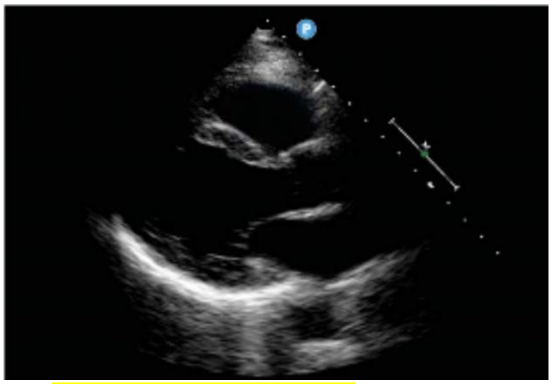
1. Which probe placement location yields the apical four-chamber view?

   a. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the right shoulder (11 o'clock)
   b. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the left shoulder (1 o'clock)
   c. in the subxiphoid region of the abdomen, tilt to the patient's left, with the index marker pointing towards the head (12 o'clock)
   d. in the 4th or 5th intercostal space, in the midclavicular line, with the index marker pointing towards the left (3 o'clock)
2. Which probe placement location yields the parasternal long axis view?
   a. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the right shoulder (11 o'clock)
   b. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the left shoulder (1 o'clock)
   c. in the subxiphoid region of the abdomen, tilt to the patient's left, with the index marker pointing towards the head (12 o'clock)
   d. in the 4th or 5th intercostal space, in the midclavicular line, with the index marker pointing towards the left (3 o'clock)
3. This image is taken from which view?

   a. Parasternal Long axis
   b. Parasternal Short axis
   c. Subcostal Long axis
   d. Subcostal Short axis
4. What structure is indicated by the orange star?



   a. Aortic valve
   b. Pulmonic valve
   c. Mitral valve
   d. Tricuspid valve
5. What view is this?



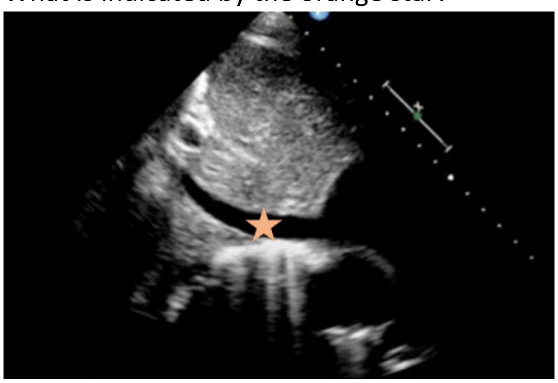
   a. Parasternal long view
   b. Parasternal short view
   c. Apical four chamber
   d. Subcostal four chamber

6. What structure is indicated by the orange star?

   a. Right atrium
   b. Left atrium
   c. Left ventricle
   d. Aorta
7. How do you obtain this view?

   a. Place transducer 2-3cm below xyphoid process, direct transducer toward the left shoulder (approximately 3 o'clock)
   b. Place transducer 2-3cm below xyphoid process, direct transducer toward the right shoulder (approximately 11 o'clock)
   c. In the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the left shoulder (2 o'clock)
   d. Place transducer 2-3cm below xyphoid process, direct transducer toward the right shoulder (approximately 11 o'clock)

8. What is indicated by the orange star?



   a. Aorta
   b. Pericardium
   c. LVOT
   d. IVC

9. What is indicated by the orange star?

   a. Right atrium

    b. Right ventricle
    c. Left atrium
    d. Left ventricle

10. What probe placement location yields the parasternal short axis view?
    a. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the right shoulder (11 o'clock)
    b. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the left shoulder (2 o'clock)
    c. in the subxiphoid region of the abdomen, tilt to the patient's left, with the index marker pointing towards the head (12 o'clock)
    d. in the 4th or 5th intercostal space, in the midclavicular line, with the index marker pointing towards the left (3 o'clock)
11. Which probe type is ideal for TTE
    a. Linear
    b. Phased array
    c. Curvilinear
    d. Hybrid
12. The proper TTE probe will scan at what frequency?
    a. Low
    b. Mid
    c. High
    d. Ultra-high
13. How do you determine that a patient will be fluid responsive from the subcostal view?
    a. "Kissing" ventricle walls
    b. Low estimated stroke volume
    c. Low venous return
    d. IVC collapse >50%
14. A ventricle that is hypodynamic will have what characteristics
    a. Decreased wall motion and increased anterior mitral leaflet movement
    b. Decreased wall motion and anterior mitral leaflet movement
    c. Increased wall motion and anterior mitral leaflet movement
    d. Increased wall motion and decreased anterior mitral leaflet movement
15. Diagnosing a large pericardial effusion can usually be accomplished by using which view?
    a. Parasternal long axis
    b. Parasternal short axis
    c. Apical four chamber
    d. Subcostal

*Question 15 thrown out of grading d/t no clear correct answer

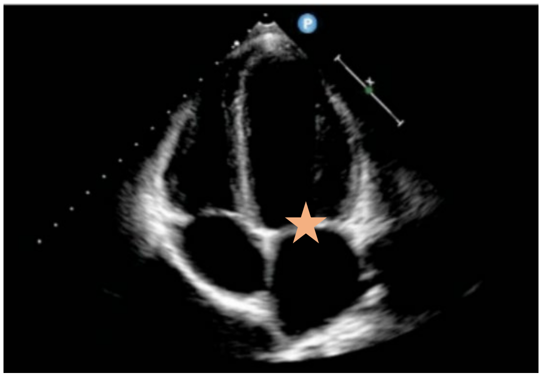
Appendix C

Post-test questionnaire

TTE Knowledge

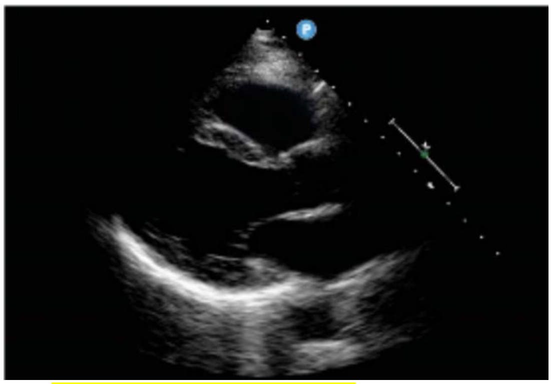
1. Which probe placement location yields the apical four-chamber view?
   e. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the right shoulder (11 o'clock)
   f. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the left shoulder (1 o'clock)
   g. in the subxiphoid region of the abdomen, tilt to the patient's left, with the index marker pointing towards the head (12 o'clock)
   h. in the 4th or 5th intercostal space, in the midclavicular line, with the index marker pointing towards the left (3 o'clock)
   i. in the 4th or 5th intercostal space, in the midclavicular line, with the index marker pointing towards the head (12 o'clock)
2. Which probe placement location yields the parasternal long axis view?
   a. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the right shoulder (11 o'clock)
   b. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the left shoulder (1 o'clock)
   c. in the subxiphoid region of the abdomen, tilt to the patient's left, with the index marker pointing towards the head (12 o'clock)
   d. in the 4th or 5th intercostal space, in the midclavicular line, with the index marker pointing towards the left (3 o'clock)
   e. in the 4th or 5th intercostal space, in the midclavicular line with the index marker pointing towards the head (12 o'clock)
3. This image is taken from which view?

   a. Parasternal Long axis
   b. Parasternal Short axis
   c. Subcostal Long axis
   d. Subcostal Short axis
4. What structure is indicated by the orange star?



a. Aortic valve
b. Pulmonic valve
c. Mitral valve
d. Tricuspid valve

5. What view is this?



a. Parasternal long view
b. Parasternal short view
c. Apical four chamber
d. Subcostal four chamber

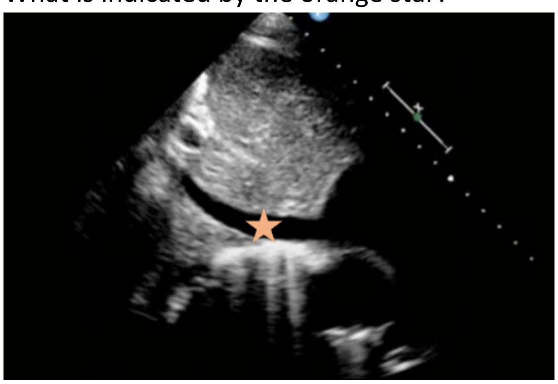
6. What structure is indicated by the orange star?

a. Right atrium
b. Left atrium
c. Aorta
d. IVC

7. How do you obtain this view?

a. Place transducer 2-3cm below xyphoid process, direct transducer toward the left shoulder (approximately 3 o'clock)
b. Place transducer 2-3cm below xyphoid process, direct transducer toward the right shoulder (approximately 11 o'clock)
c. In the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the left shoulder (2 o'clock)
d. Place transducer 2-3cm below xyphoid process, direct transducer toward the right shoulder (approximately 11 o'clock)

8. What is indicated by the orange star?



a. Aorta
b. Pericardium
c. LVOT
d. IVC

9. What is indicated by the orange star?

a. Right atrium

b. Right ventricle
c. Left atrium
d. Left ventricle
e. Aorta
f. IVC

10. What probe placement location yields the parasternal short axis view?
    a. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the right shoulder (11 o'clock)
    b. in the 3rd or 4th intercostal space, at the left parasternal border, with the index marker pointing towards the left shoulder (2 o'clock)
    c. in the subxiphoid region of the abdomen, tilt to the patient's left, with the index marker pointing towards the head (12 o'clock)
    d. in the 4th or 5th intercostal space, in the midclavicular line, with the index marker pointing towards the left (3 o'clock)
    e. in the 4th or 5th intercostal space, in the midclavicular line with the index marker pointing towards the head (12 o'clock)
11. Which probe type is ideal for TTE
    a. Linear
    b. Phased array
    c. Curvilinear
    d. Hybrid
12. The proper TTE probe will scan at what frequency?
    a. Low
    b. Mid
    c. High
    d. Ultra-high
13. How do you determine that a patient will be fluid responsive from the subcostal view?
    a. "Kissing" ventricle walls
    b. Low estimated stroke volume
    c. Low venous return
    d. IVC collapse >50%
14. A ventricle that is hypodynamic will have what characteristics
    a. Decreased wall motion and increased anterior mitral leaflet movement
    b. Decreased wall motion and anterior mitral leaflet movement
    c. Increased wall motion and anterior mitral leaflet movement
    d. Increased wall motion and decreased anterior mitral leaflet movement
15. Diagnosing a large pericardial effusion can usually be accomplished by using which view?
    a. Parasternal long axis
    b. Parasternal short axis
    c. Apical four chamber
    d. Subcostal

*Question 15 thrown out of grading due to no clear correct answer

Appendix D

Skills check-off

Skill	**Completed?**
Obtain the parasternal long axis view	
Identify: Right ventricle	
Left ventricle	
Left atrium	
Aorta	
Mitral valve	
Aortic valve	
Obtain the parasternal short axis view	
Identify: Right atrium	
Right ventricle	
Mitral valve	
Left ventricle	
Obtain the apical four-chamber view	
Identify: Right atrium	
Left atrium	
Right ventricle	
Left ventricle	
Mitral valve	
Tricuspid valve	
Obtain the subcostal four-chamber view	
Identify: Right atrium	
Left atrium	
Right ventricle	
Left ventricle	

Mitral valve	
Tricuspid valve	
Obtain the subcostal inferior vena cava view	
Identify: Right atrium	
Inferior vena cava	
Pathology	
Identify the following pathologies:	
Hypovolemia	
Ventricular dysfunction	
Pericardial effusion	
Aortic stenosis	

Appendix E

Attitudes survey

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1. Using TTE during non-cardiac surgery is beneficial for intraoperative decision making	1	2	3	4	5
2. The usefulness of intraoperative TTE is mostly limited to cardiac surgery	1	2	3	4	5
3. I will implement in the near future or have implemented non-cardiac TTE into my practice	1	2	3	4	5
4. I would like to continue to learn about the use of TTE for troubleshooting during surgery	1	2	3	4	5
5. This course was successful in increasing my proficiency with TTE	1	2	3	4	5
6. I am comfortable diagnosing hypovolemia with TTE	1	2	3	4	5
7. I am comfortable diagnosing reduced ventricular function with TTE	1	2	3	4	5
8. I am comfortable with selecting the right probe for performing bedside TTE	1	2	3	4	5

Appendix F

Budget

Nature of Expenditure/Item	Cost per Unit	# Units	Total Estimated Cost
Direct Costs			
Personnel			
Team Chair - CRNA	$90.96	60	**$5,457.60**
Team Member 1 – CRNA	$90.96	40	**$3,638.40**
Team Member 2 - Anesthesiologist	$130.50	40	**$5,220.00**
Training CRNAs	$90.96	50	**$4,548.00**
Materials and Supplies			
Office Supplies	$20.00	1	**$20.00**
Printing	$0.05	200	**$10.00**
Technology Hardware/Software			
SPSS Software	$77.00	1	**$77.00**
Qualtrix	$0.00	1	**$0.00**
Microsoft Office Suite	$149.00	1	**$149.00**
Other			
TTE Simulation Mannequin Use	$0.00	1	**$0.00**
TOTAL			**$19,120**

Appendix G

Timeline of Project

Task	08/21	09/21	10/21	11/21	12/21	01/22	02/22	03/22	04/22
IRB Approval	X								
Module Development	X	X							
Participant Selection		X							
Pretest/demographic survey sent		X							
Computerized module sent			X						
In-person simulation			X						
In-person checkoff				X					
Posttest and attitudes survey sent				X	X	X			
Data Analysis						X	X		
Drafting of Final Paper/Presentation							X	X	
Dissemination of Final Paper/Presentation								X	X