Online Continuing Education Module Transthoracic Echocardiogram

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Abstract

A Transthoracic Echocardiogram (TTE) is the utilization of an ultrasound probe to obtain five different views of the heart (Aurora Health Care, 2022). A TTE allows the anesthesia provider to assess a patient's cardiac ventricles and valves in real-time to elicit information about fluid status, ejection fraction, and rhythm abnormalities. Several observational, pilot, and case studies have shown both hands-on and computer-based training for TTE have been implemented in healthcare education (Anderson et al., 2021; Bhatia et al., 2017; Elison et al., 2020; Goldstein et al., 2020; Goldstein et al., 2021; Haskins et al., 2017; Hempel et al., 2020; Kline et al., 2021; Sanders et al., 2019; Shields & Gentry, 2020). The studies demonstrate how effectively these methods improve TTE skills and knowledge in nurse anesthesia and physician residency programs. Applying this information allows the provider to determine fluid requirements and hemodynamic condition and assess changing cardiac rhythm during the perioperative care period. Certified registered nurse anesthetists (CRNAs) are required to complete continuing education (CE) modules to maintain their licensure through the National Board of Certification and Recertification for Nurse Anesthetists (NBCRNA). CE is critical to developing skills and gaining knowledge for all anesthesia providers. This project developed a CE module to teach student registered nurse anesthetists (SRNAs) and CRNAs how to perform a basic TTE to obtain the five views of the heart. AdventHealth University (AHU) SRNAs developed an evidence-based educational module regarding TTE assessment for publication in AHU Echelon and received CE credit approval from the American Association of Nurse Anesthetists (AANA) in September 2023.

Contents

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A Transthoracic Echocardiogram uses ultrasound technology to evaluate a patient's cardiac status through a non-invasive scan (Goldstein et al., 2020). Generally, the scan is performed during hospitalizations or in an outpatient clinic by a sonographer or cardiologist. To decrease the rate of poor clinical outcomes, patients with a history of cardiac issues or questionable hemodynamic stability undergo an echocardiogram in the weeks or months before their planned surgery. However, during the time between the cardiac assessment and the date of surgery, patients have the potential to decompensate without being noticed by a clinician. If anesthesia providers, specifically Certified Registered Nurse Anesthetists and Student Nurse Anesthetists, are taught to perform a TTE, expanding their knowledge and skill level can reduce the adverse surgical outcomes of the at-risk patient population.

Significance and Background

A TTE can assess the hemodynamic function of the heart in real-time before surgery and assist in developing an appropriate anesthetic plan specific to the patient's needs (Haskins et al., 2017). Education for CRNAs includes advanced assessment of the heart and lungs combined with a deep understanding of the anatomy and physiology of the human body. CRNAs are licensed to use ultrasounds for guided images of line placements and to perform thorough patient assessments, including TTE (Tharp, 2023). CRNA didactic learning is complimented with clinical simulations and hands-on training. Nurse anesthetists are a resource for healthcare; to perform within their full scope of practice allows them to provide coverage in all settings, such as ambulatory, clinics, offices, and out-of-operating room locations (Vitale, 2021). CRNAs are more accessible to patients from rural areas and are more likely to come across vulnerable patients. To provide safe and effective anesthesia for those patients, it is prudent that CRNAs

practice to their full capabilities.

A knowledge gap for CRNAs with TTE experience must be addressed (Tharp, 2023). TTE is an evolving field for perioperative assessment to check a patient's fluid status, contractility, embolisms, valve disorders, and heart function (Haskins et al., 2017). These conditions can lead to hypotension and arrhythmias during surgery. It is important to obtain the patient's entire medical history and status to administer a safe anesthetic to the patient. According to the American Association of Nurse Anesthesiology's Standards of Care, the nurse anesthetist must evaluate a patient's general health and preexisting conditions before, during, and in the post-anesthesia period (American Association of Nurse Anesthesiology, 2019). CRNAs perform all their patient evaluations, and in rural areas where they are the sole anesthesia provider for the facility, they use the available resources to make a judgment. The TTE can equip the provider with important information for their anesthetic plan and be a valuable tool in a comprehensive patient assessment.

Despite the benefits of learning to use a TTE, there is a knowledge gap among CRNAs who know how to perform an echocardiogram (Tharp, 2023). Online simulation modules are a new component of modern-day learning (Haskins et al., 2017). As healthcare professionals, it is imperative to facilitate the progression of medical care and patient safety. Education revolves around both in-person and online advancements. This scholarly project is aimed at providing an online platform for TTE education. The basics of the TTE must be accessible for nurse anesthetists as this will benefit all clinicians, patients, and the future of the nurse anesthesia practice.

PICOT Questions

Two questions were posed in PICOT format (Melynk et al., 2017). The first question

addresses the problem: For student registered nurse anesthetists (SRNAs) and certified registered nurse anesthetists (CRNAs) (P), does continuing education of transthoracic echocardiogram (I) increase the competency level with the usage of cardiac ultrasounds perioperatively (O)?

The second question addresses the innovation: Can AdventHealth University (AHU) student registered nurse anesthetists (P) who develop an evidence-based educational module regarding transthoracic echocardiogram assessment for publication in AHU Echelon (I), receive AANA CE credit approval by December 2023 (O) (Melynk et al., 2017)?

Search Strategy

The following databases were used for the search strategy: Google Scholar, ScienceDirect, and PubMed. A total of 2,710 articles were initially retrieved, with 11 articles that met the defined search criteria. Inclusion criteria consisted of peer-reviewed studies containing the key search terms in the English language within the last five years. Key search terms and MeSH combinations included: *transthoracic echocardiogram, TTE, preoperative assessment, education, anesthesia, nurse anesthesia, and TTE effectiveness*. Search terms were limited to TTE, nurse anesthesia, education, effectiveness, and preoperative assessment.

Grade Criteria

The grading recommendations assessment, development, and evaluation (GRADE) criteria assisted in distinguishing and analyzing researched articles (Melynk et al., 2017; Roush, 2020). The GRADE criteria facilitated the determination of applicability and reliability for the articles in the literature review. Limitations to the GRADE criteria included: within a five-year publication timeframe, case studies of educational interventions related to teaching TTE, and subjects who are medical providers. Methodological flaws included having subjective data in establishing improvement results and the small population size utilized in all the available

studies, which resulted in imprecision. Inconsistencies in the studies included unclear results, lack of specificity in determining whether improvement occurred, and the lack of research to determine which intervention has the most significant impact on improving TTE skills (Sanders et al., 2019). In summary, research on determining the efficacy of online modules is in its nascent stages; therefore, limited qualified literature exists. Thus, the quality of evidence is moderate, but all indicate support for utilizing Continuing Education (CE) modules to address the knowledge gap among anesthesia providers (see Appendix A).

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Literature Review & Synthesis of Evidence

A TTE projects five different views of the heart via an ultrasound wand applied to the external surface of the sternum. A trained medical professional such as a CRNA or SRNA can assess the TTE to find the current condition of a patient's fluid and hemodynamic status, which is essential in determining an individualized anesthetic plan (Haskins et al., 2017). This is crucial for at-risk patients who have not seen their cardiologist in the months before an elective procedure and for patients who arrive needing urgent surgery but have a questionable history. The anesthesia provider's role is to optimize the patient and diminish the risks associated with surgery, particularly in emergent cases (Goldstein et al., 2021). However, TTE continues to be an underutilized resource due to a knowledge gap among anesthesia providers, despite current literature stating that it has an impact on altering planned anesthesia management (Markin et al., 2015). Based on the reviewed literature, studies indicate utilization of CE modules increases the anesthesia provider's competency with TTE performance (Goldstein et al., 2020; Shields & Gentry, 2020).

To improve upon this identified deficit, there has been an increasing demand for anesthesia providers to use TTE (Elison et al., 2020). A CE module for TTE has been identified

as a beneficial and cost-effective intervention (Goldstein et al., 2020). The difficulty with obtaining a TTE lies in the psychomotor skills of the user. Providing a simulation with the CE module gives the user a knowledge base on the technique and expected image projection (Anderson et al., 2021; Bhatia et al., 2017; Elison et al., 2020; Goldstein et al., 2020; Goldstein et al., 2021; Haskins et al., 2017; Hempel et al., 2020; Kline et al., 2021; Kratz et al., 2017; Margale et al., 2017; Sanders et al., 2019; Shields & Gentry, 2020; Subramaniam et al., 2022). The use of ultrasound-guided assessments is in growing demand and utilizing it for a thorough cardiac exam will increase patient safety.

Companies from various backgrounds have utilized online training; since the effects of COVID-19, there has been a surge in demand for online education (Kline et al., 2021). Healthcare professionals rely on CE modules to stay current with new medicine, technology, and safety practices (Rosen et al., 2012). Effectively structured online CE modules help users to learn and understand new material through interactional education tools to assist them in engaging with their actual work environment (Huddlestun et al., 2021). TTE has been implemented in medical student curriculums through online training for anesthesiology residents and physicians (Bhatia et al., 2017; Haskins et al., 2017; Hempel et al., 2020; Sanders et al., 2019). The expansion of TTE training to CRNAs and SRNAs through the creation of an online CE module will enhance anesthesia care by broadening the scope of practice and addressing the knowledge gap on TTEs to a wider professional population (Kline et al., 2021).

This project complies with the American Association of Nurse Anesthesiology (AANA) standards to practice quality improvement for CRNAs and SRNAs (AANA, 2013). AdventHealth University (AHU) faculty share the AANA's position that it is standard for nurse anesthetists to implement new evidence-based practices to provide optimal care and formulate a

safe anesthesia plan. In previous projects, it has been found that 1-hr CE modules created by SRNAs from AHU are feasible and can be extrapolated to address existing knowledge gaps (Huddlestun et al., 2021). Therefore, this project focuses on filling in the knowledge gap on TTE performance and indicating its use by nurse anesthetists.

Two models formed the theoretical framework that guided the design of this scholarly project. The two models within this framework of use included the Advancing Research and Clinical Practice through Collaboration (ARCC) model and Promoting Action/Research in Health Services (PARISH) framework. The ARCC model guides researchers in assessing the readiness for and implementation of a system into healthcare use, identifying facilitators and barriers to this evidence-based practice, and then evaluating the outcomes of the practice (Melnyk et al., 2017). The PARISH framework provides researchers with a way of judging the quality of both the evidence supported by literature and the context addressed in the PICOT questions (Melynk et al., 2017). Finally, the framework combines the evidence and the question context to support facilitation and implementation.

After completion of the literature review, enough evidence supported an indication to create a CE module to educate healthcare providers on TTEs. Subjects can practice and retain information from hands-on CE module training (Hempel, et al., 2020). Although the implementation of TTE use by anesthesia providers exists, there is insufficient research in determining a specific solution to close the knowledge gap on TTEs. In addition, the impact of knowledge gained from the project will likely expand the skillset of CRNAs and SRNAs, thus decreasing adverse patient outcomes and increasing the quality of perioperative care.

Project Aims

This scholarly project was for AHU SRNAs who developed an evidence-based

educational module regarding TTE assessment for publication by AHU Echelon and received AANA CE credit approval by December 2023. This aim was accomplished in September 2023. Another accomplished objective was to obtain permission from the University of Toronto (pie.med.utoronto.ca) and Pocus101 (pocus101.com) to use their images and videos for the module by June 2022. The remaining objectives were to determine a budget for the development of the TTE assessment CE module, complete the evidence-based CE module with the team at Echelon by January 2024, and to complete the research and planning document by April 2024.

Methods

This scholarly project took place at AHU and did not follow the traditional research design. The project focused on developing a CE module and the application process to receive national accreditation. An online CE module was created and published on the Echelon website to enhance the CRNAs' and SRNAs' knowledge and training in the use of TTE. No human subjects or statistical methodology were used in the creation of the CE module. The module design included the development of multiple-choice formatted questions on the pre-test and post-test, which the end-user will experience after the completion of this study. Therefore, informed consent was not required.

The collaboration with Echelon and formulation of an online CE module influenced the decision to combine the ARCC and PARISH frameworks. The purpose of this project was to enhance the subject’s knowledge of TTE and to apply the gained information in a clinical setting. The ARCC model utilizes an organized format to educate the masses over an extended period (Melnyk et al., 2017). To support the evidence found in the literature, a PARISH model judges the quality and context of evidence, and further considers other avenues of transferring information (Melynk et al., 2017). In this project, the online CE module created uses a

combination of audio, visual, and online interactive learning, thus facilitating the implementation of information in multiple ways (Ulrich et al., 2010).

The information obtained for the direction of this scholarly project came from interviews with key players and experts in CE module creation at Echelon. Information from these collaborators was collected through Zoom interviews, in-person discussions, and email exchanges. All information received during interviews and emails was stored on the interviewers' personal, secured electronic devices. None of the information obtained during these meetings was shared with sources other than those directly involved in creating this scholarly project. All personal data, including recordings used in the study, will be deleted from personal computers after seven years per AHU IRB.

The CE module was created with the information and discussions that occurred during those meetings with key players and experts in CE module creation at Echelon. This project was successfully accredited by the AANA in September of 2023.

Planning and Procedures

The initial planning involved completing a literature review about TTEs and determination of their significance and demand in the perioperative arena. Based on the compiled evidence, there is a demand for providers to acquire experience with ultrasound use to evaluate cardiac function and abnormalities as it improves patient outcomes (Markin et al., 2015). The key stakeholders identified for this project included the faculty from Echelon and AHU. Dr. Steven Fowler, former associate professor, and former project chair in the AHU Doctor of Nurse Anesthesia Practice program, who organized a timeline with Echelon for autobiographies, resumes, and filling out necessary documents to kickstart this project. Lori Polizzi, Echelon director, Julie Talmadge, accreditation coordinator at Echelon, and Dr. Jennifer Huddlestun were

the facilitators for this project and guided resource utilization for project success. The budget plan was to cover expenses by applying for a grant from AHU or through out-of-pocket expenses if a grant was not achieved. Budgetary expenses for the media creation of the CE module for publication were covered through the Echelon program partnership with AdventHealth and AdventHealth University. The barriers and limitations to the completion of this project were addressed as a team, directed by our Project Chair's guidance. The project timeline did not endure any significant changes from the original sequence of events. Therefore, the project will serve as a guideline for future CE module projects.

Planning and Implementation

The topic for the CE was approved by Echelon and AHU so that the content experts could create a PowerPoint and script for the educational portion of the CE module. Module content was derived from the literature and content expert interviews. During this time, the questions for the pre- and post-test were determined for the CE module. Once the final content media is published, the formulated content questions will be tested with six sample end-users. After it is published, the stakeholders will evaluate the data once it is obtained from the end-user assessment to determine if the scholarly project objectives were achieved. The students and key players will present the reviews obtained from the end-users.

The content experts intended to apply for an education grant through AHU to cover the fees associated with the submission of the AANA Continuing Education Application. The original educational grant request, in the amount of $150, became irrelevant once the investing partnership with the Echelon team assumed the costs of the CE Module production. All echocardiographic images in the CE module were obtained from pie.med.utoronto.ca and pocus101.com/cardiac-ultrasound-echocardiography-made-easy-step-by-step-guide. The former

project chair, Dr. Steve Fowler, received permission from Dr. Gordon Tait from the University of Toronto to use their products under the condition to advertise and link the website resource for all reproduced images. Additionally, Dr. Fowler received permission from Dr. Vin Dinh, creator of the Pocus101.com cardiac ultrasound guide, to use his images and videos for the CE module content. The Echelon marketing team projection estimates the cost to publish a completed CE module to be $6,000, which was assumed by the partnership investment and collaboration with the Echelon team.

Barriers and Facilitators

Thorough interviews were conducted with the key stakeholders to identify potential barriers and other potential facilitators to creating a CE module. Barriers addressed for this CE module included time management of SRNA students in CRNA school and closed-loop communication via in-person and electronic correspondence. Other considerations ensuing from this scholarly project included difficulties acquiring all necessary documentation, acquiring AHU staff signatures, and navigating the political culture of anesthesia providers within the AdventHealth system as they relate to the CRNAs' scope of practice. To attenuate these barriers, project content experts designated one person to email Lori Polizzi and Julie Talmadge with updates and documents. Also, former project chair Dr. Steve Fowler created a TTE folder in Microsoft Teams containing all the necessary forms to complete, and the project content experts communicated with the scholarly participants and committee members.

The barriers of this project include the limited published literature specific to SRNA/CRNA simulation-based training on using TTEs, and the extensive time commitment required to create a CE module with Echelon that would achieve AANA accreditation approval. Another limitation in this project was resourcing and acquiring permission for images and videos

of TTE views approved for publication within the module. The content experts received permission from the University of Toronto Medicine to use their website http://pie.med.utoronto.ca/tte/, which was developed by a Physiologist, a Cardiovascular surgeon, a group of Cardiologists, medical artists, and web developers, who have done an excellent job explaining the physiologic structures found on the echocardiographic views. The website used 3D simulation to assist the user with pertinent information and applicable instructions to reproduce the techniques discussed. The content experts also received permission from Dr. Vin Dinh, FACEP, RMS, RDCS, to use echocardiography images from https://pocus101.com/cardiac-ultrasound-echocardiography-made-easy-step-by-step-guide and from Dr. Gordon Tait, PhD, to use images from https://pie.med.utoronto.ca/.

Timeline

In June 2022, the site approval letter from Echelon for the CE module was received by former Project Chair Dr. Steve Fowler, CRNA. Dr. Fowler then assigned a group of students from the AHU Class of 2024 and explained the details of creating a CE Module. At this point, the SRNAs transitioned to content experts and began producing an outline for a TTE CE module. In June of 2023, the SRNAs Michael, Arun, and Angelina met with representatives from Echelon with an approved CE module outline to submit the project proposal to the AANA for accreditation determination. The AANA approved the CE module for accreditation in September 2023. On November 2nd, 2023, the Echelon media team began development and construction of the CE module for publication. The expected release date of the CE module on the Echelon platform was January 2024. However, due to production and permission clarifications, the final CE module will be available on the Echelon website in February 2024. (See Appendix F for completed timeline)

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Discussion & Implications

The lack of TTE education and training for CRNAs led to a knowledge gap in skills despite having the license to perform a diagnostic image as an anesthesia provider (Tharp, 2023). A TTE is a safe and non-invasive procedure that provides real-time hemodynamic information about the patient. In the case of a high-risk patient needing surgery, findings on the TTE can influence the anesthetic plans for the patient (Goldstein et al., 2020). The purpose of this project was to present online information for anesthesia providers regarding the five basic TTE views, how to obtain them, and when to suspect an at-risk patient who would benefit from a TTE.

Applicability to Practice & Contribution to Growth

The nurse anesthetist is responsible for providing safe and quality care for their patients before, during, and after surgery (American Association of Nurse Anesthesiology, 2019). Patients requiring urgent or emergent surgery often present with hemodynamic instability. Additionally, patients with chronic cardiac issues may not have received any cardiac monitoring or assessment in the months before elective surgery. To mitigate surgical risk, a TTE would give an understanding of the patient's physiological condition and contribute information to optimize the anesthesia provider's patient-specific plan of care. Therefore, TTE can be extrapolated to improve patient outcomes, save hospital costs on unnecessary medical interventions, improve patient safety and surgical experience.

This CE module intended to further the growth of the CRNA skillset by addressing the knowledge gap on TTE usage in the preoperative setting, provide an opportunity to expand their skills, and promote patient safety with an expansion of diagnostic tools to assess an at-risk patient’s status by obtaining real-time data.

No data was collected during the creation of the CE module, as it differs from traditional

research project procedures. This project was completed on February 6th, 2024. Subject users from the AHU DNAP cohort of 2024 are testing the module and will provide feedback prior to publication to the target population.

Conclusion

Undetected heart conditions can lead to adverse events in a perioperative setting, which cause negative patient outcomes (Jariwala et al., 2022). Even if a patient received cardiac clearance, they could still have an undetected myocardial infarction (MI) before surgery. Some patients may wait for a month or two after cardiac clearance, and in that timeframe, their heart condition worsens. A TTE can provide a quick and easy solution to pending doubts about a high-risk patient's condition. Cardiac ultrasound information is vital to developing a safe anesthetic plan, and the provider can anticipate hemodynamic changes under anesthesia. The TTE not only serves to improve patient outcomes and satisfaction, it also allows the CRNA an opportunity to perform at their highest capabilities.

CRNAs are more likely to take on vulnerable patients in rural areas where they are solely reliable for the management of patients (Vitale, 2021). It is essential to close the knowledge gap in CRNA education for cardiac ultrasound training to help providers to be skilled in their scope of practice. Literature shows that online simulation yields positive results when complimented with hands-on experience (Bhatia et al., 2017; Haskins et al., 2017; Hempel et al., 2020; Sanders et al., 2019). This scholarly project can facilitate the advancement of anesthesia training and teach providers a basic understanding of the TTE, and learn to obtain the five basic views of the heart, which can provide accurate and real time patient information.

Dissemination Plan

After reviewing feedback from subject users, the module will be available for SRNAs

and CRNAs to complete through the Echelon website for 1.5 hours of continuing education credit. The project developers will have a formal presentation to the AHU DNAP program on March 26th and 27th of 2024 after receiving feedback from their test users. There will be no data collection in this scholarly project.

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Purpose	Variables	Setting/Subjects	Measurement and Instruments	Results	Evidence Quality
Study 1: To determine if medical students can learn basic skills of TTE from a simulator led curriculum, how skills improve, and the rate at which these skills are acquired. (Elison et al., 2020) **Study 2:** To assess usage of a 5-week point-of-care TTE workshop for medical students. (Goldstein, et al., 2021)	**Study 1**: **Independent variable**: Simulator based US curriculum with hands-on training **Dependent variable**: How a student's view of specific cardiac views improves through use of a simulator **Study 2**: **Independent variable:** The 5-week course used to measure efficacy of TTE **Dependent variable:** Measurements of a student's improvement by examinations assessing hands-on performance of TTE views, anatomy, and knowledge.	**Study 1**: Forty-one medical students participate in an elective simulator course through learning via didactic material mixed with hands-on training. **Study 2**: Took place in a US medical school with 4 second year and 4 third year students.	**Study 1**: Measurements were done using a simulation mannequin with a mock transducer tracking its location via a magnetic field system. "Change in psychomotor skill growth was assessed using comparative angle error for each student, in each view, as well as the group's mean angle error for each view and all scans. These mean values were compared pretesting, interim testing, and post-testing using Student's *t* test." (Elison et al., 2020, pg. 493) **Study 2**: Two exams were given to measure mean and standard deviation of the ability to obtain the basic four focus assessed transthoracic echocardiography (FATE) views, anatomy identification, and written questions. The first exam occurred at the beginning of week one and the second occurred at end of week 5.	**Study 1**: "Average angle error improved from 43° ± 24 pretraining to 23° ± 16 post-training, with most students falling within one SD. Rate of skill acquisition, an angle error of 43 ± 24° (pre) changed to 22 ± 14° (interim test, $P < .0001$ vs. pretest) and remained at that level for the post-test evaluation on both the repeated case (23 ± 16°) and the new case (26 ± 18°)." (Elison et al., 2020, pg. 491) **Study 2**: Mean and standard deviation (§SD) total examination scores increased to 83.6 (§5.2) after the workshop versus 54 (§7.1) at baseline ($p < 0.0001$). Mean (§SD) practical examination scores increased to 38 (§2.5) after the workshop versus 22 (§4.6) at baseline ($p < 0.0001$). Mean (§SD) written examination scores increased to 46 (§4.8) after the workshop versus 32 (§5.8) at baseline ($p = 0.0003$). (Goldstein et al., 2021, p. 826)	**Methodological flaws:** **Study 1**: None **Study 2**: Small sample size. **Inconsistency:** **Study 1**: None **Study 2**: None **Indirectness:** **Study 1**: Study was done for medical students only. **Study 2**: Study was done for medical students only **Imprecision:** **Study 1**: None **Study 2**: None **Publication bias** **Study 1**: Dr. Sheehan who is the founder and president of Sheehan Medical LLC which markets the TTE simulator used in this study. However, none of the co-authors are a part of Sheehan Medical LLC and receive no benefits or sales of their products. **Study 2**: None
Design:				Implications	
Study 1: Data obtained through an elective course offering a simulator-based didactic with hands-on practice utilizing transthoracic echocardiogram to accurately view the heart and valves from four views. **Study 2**: Prospective, time-series design.				**Study 1**: To show that this method of instruction can lead to quick acquisition and proficiency in focused cardiac ultrasound imaging and interpretation. **Study 2**: The workshop showed value in effectively teaching and improving the skill level of TTE utilization for medical students who participated in the 5-week workshop	

Hempel, C., Turton, E., Hasheminejad, E., Bevilacqua, C., Hempel, G., Ender, J., & Rotzoll, D. (2020). Impact of simulator-based training on acquisition of transthoracic echocardiography skills in medical students. Annals of Cardiac Anaesthesia, 23(3), 293-297. https://doi.org/10.4103/aca.ACA_51_19

Kline, J., Golinski, M., Selai, B., Horsch, J., & Hornbaker, K. (2021). The effectiveness of a blended POCUS curriculum on achieving basic focused bedside transthoracic echocardiography (TTE) proficiency. A formalized pilot study. *Cardiovascular Ultrasound*, *19*(1), 1-7.

Purpose	Variables	Setting/Subjects	Measurement and Instruments	Results	Evidence Quality
Study 1: To determine and compare simulator-based training with didactic learning of focused TTE examination among medical students. (Hempel et al., 2020) **Study 2**: Evaluating an existing educational platform of didactic and hands-on training for SRNAs in the basic identification and performance of TTE. (Kline et al., 2021)	**Study 1:** **Independent variable:** Simulation learning module and hands-on training. **Dependent variable:** Pre and posttest scores comparing simulation vs. hands-on TTE training. **Study 2**: **Independent variable**: didactic presentation and hands-on TTE simulation **Dependent variable**: Pretest and posttest	**Study1:** Twenty-two (3rd and 4th year) medical students at Leipzig University completing a simulation learning module and a hands-on training session of TTE. **Study 2**: Twenty-six SRNAs who volunteered to participate in an additional point-of-care ultrasound (POCUS) curriculum.	**Study 1:** Medical students took a 90-minute simulation-based learning module on focused echocardiography and pathologies with a questionnaire. Followed by a 120-minute TTE practical training session. After which a post test was given to assess learning. **Study 2**: SRNA's were given a pre-test before the curriculum took place to measure their baseline understanding of the four basic views of common TTE. SRNA's then received a one-hour didactic presentation of TTE and a second additional hour of hands-on simulation. Then followed by a posttest to determine changes in score by using t-test scoring for analysis.	**Study 1:** Pre and posttest training scores showed little variation between simulation (SIM) training and human model (MOD) training. Pre-training test: SIM=12.4/15[1.27], MOD= 12.5/15[1.31] Post-training overall result of FATE examination: SIM=16.95/25[3.71], MOD=15.54/25[2.52] (Hempel et al., 2020, pg. 295) **Study 2**: Pretest scores (M = 58.65, SD = 23.66) for interpreting the four most common TTE images. Posttest scores (M = 95.19, SD = 9.41) of the same images after the blended curriculum [observed t statistic 7.24, $P < 0.001$; 95% CI [26.15, 46.93] (Kline et al., 2021, pg. 4)	**Methodological flaws:** **Study 1:** None **Study 2**: Pretest and posttest were identical. **Inconsistency:** **Study 1:** None **Study 2**: None **Indirectness:** **Study 1:** None **Study 2**: None **Imprecision**: **Study 1:** None **Study 2**: None **Publication bias** **Study 1:** None **Study 2**: A co-investigator was also the primary curriculum presenter.
Design:				Implications	
Study 1: The design was not stated but appears to be a formalized pilot study. **Study 2**: A formalized pilot study				**Study 1:** No significant difference in skill outcome between simulation training and human model training with TTE. **Study 2**: The existing educational training program used to achieve the 4 basic views of TTE is an effective method to teach SRNAs for utilization at the bedside.	

Goldstein, S., Feierman, D. E., Samayoa, G. M., Roth, R., Delphin, E., Gubenko, Y. A., Stohl, M., Rimal, J., Botea, A., Zweig, R., & Skubas, N. J. (2020). Assessment of didactic transesophageal echocardiography education during anesthesia residency. *The Journal of Education in Perioperative Medicine*, *22*(3), E644. https://doi.org/10.46374/volxxii-issue3-Goldstein

Sanders, J. A., Navas-Blanco, J. R., Yeldo, N. S., Han, X., Guruswamy, J., & Williams, D. V. (2019). Incorporating perioperative point-of-care ultrasound as part of the anesthesia residency curriculum. *Journal of Cardiothoracic and Vascular Anesthesia*, *33*(9), 2414-2418.

Purpose	**Variables**	**Setting/Subjects**	**Measurement and Instruments**	**Results**	**Evidence Quality**
Study 1: To investigate if TEE-related knowledge could be acquired during anesthesia residency. **Study 2:** To establish if implementing a POCUS program for in-training anesthesia residents during their cardiac anesthesia month was feasible and improve their baseline knowledge & technical skills with POCUS.	**Study 1:** The primary prospective outcomes were a change in exam scores within each class after the 41-week TEE course and a correlation between scores on the educators' exam and the NBE's PTEexam. A secondary outcome was a change in exam scores after the 23-week curriculum. **Study 2:** The primary outcome was an improvement from pre- and post-exam scores after a 4-week intensive workshop.	**Study 1:** 2-US based anesthesia residency programs (Rutgers New Jersey Medical School-Newark & Maimonides Medical Center). 68 Clinical anesthesia residents. **Study 2:** A tertiary-care, university-affiliated hospital in the United States. Sixteen anesthesia residents during their third postgraduate training year who were undergoing their required cardiac anesthesia rotation from July 2017 to November 2018.	**Study 1:** Baseline and post-course knowledge for the 41-week curriculum was assessed with an exam created by 3 authors skilled in TEE. It consisted of 20 video-based questions and 70 multiple-choice text-based questions for a maximum possible score of 100 points. **Study 2:** A 21-question, multiple-choice, electronic-generated test was developed to gauge performance improvement from before ("pretest") to after ("posttest") the 4-week period.	**Study 1:** After the 41-week course, exam scores increased 12% among CA-3's (P = .03), 29% among CA-2's (P = .007), and 25% among CA-1's (P = .002). After the 23-week course, the increase in scores in the original CA-1 class were maintained (P =.004) but did not increase further (P = .82), while scores in the original CA-2 class reverted to baseline (P = .31). **Study 2:** Of the 16 residents, 13 (81%) showed an improved score between the pretest and posttest after the 4-week rotation. The mean for the pretest and posttest, including 95% confidence intervals. The difference between the pretest and posttest mean scores was 5 (p = 0.001).	**Methodological flaws:** **Study 1:** Small study, curriculum lengths. **Study 2:** Small, single institution and cohort study. **Inconsistency:** **Study 1:** First year was 41-week program, second year was 23-weeks. **Study 2:** No CI **Indirectness**: **Study 1:** Hands-on, intensive workshop on TEE for anesthesiology residents. **Study 2:** Hands-on, intensive workshop for anesthesia residents. **Imprecision:** **Study 1:** No CI **Study 2:** No CI **Publication bias:** **Study 1:** None **Study 2:** None
Design				**Implications**	
Study 1: 2-year, prospective, observational study. **Study 2:** A single-center, prospective, cohort, and observational study.				**Study 1:** The 41-week course resulted in significant increases in exam scores. Therefore, integrating echocardiography education can prepare residents for boards examinations and to care for the growing older and sicker patient population. **Study 2**: Integrating a curriculum dedicated to perioperative POCUS of the heart and lungs as part of the goals and objectives during the rotation of cardiac anesthesia is feasible and that anesthesia residents who received training improved their cognitive and technical POCUS skills.	

Bhatia, R. S., Ivers, N. M., Yin, X. C., Myers, D., Nesbitt, G. C., Edwards, J., Yared, K., Wadhera, R. K., Wu, J. C., Kithcart, A. P., Wong, B. M., Hansen, M. S., Weinerman, A. S., Shadowitz, S., Elman, D., Farkouh, M. E., Thavendiranathan, P., Udell, J. A., Johri, A. M., . . . Weiner, R. B. (2017). Improving the appropriate use of transthoracic echocardiography: The echo WISELY trial. *Journal of the American College of Cardiology*, *70*(9), 1135-1144. https://doi.org/10.1016/j.jacc.2017.06.065

Shields, J. A., & Gentry, R. (2020). Effect of simulation training on cognitive performance using transesophageal echocardiography. *AANA Journal*, *88*(1), 59-65.

Purpose	**Variables**	**Setting/Subjects**	**Measurement and Instruments**	**Results**	**Evidence Quality**
Study 1: To investigate the impact of an AUC-based educational intervention on outpatient TTE ordering by cardiologists and primary care providers. **Study 2:** To assess if knowledge acquisition on using TEEs is better accomplished through simulator vs. online or web-based learning.	**Study 1:** Proportion of TTEs ordered post - educational intervention based on 2011 AUC guidelines. **Study 2:** The TEE simulation training for each group took place over a 4-week period, with a group of 8 students trained by simulator and a group of 8 students trained by online simulation each week.	**Study 1:** One hundred and ninety-six physicians were randomized, and 179 were included in the analysis from December 2014 to April 2016. The providers practiced ambulatory care at 8 hospitals, 7 in Ontario, Canada, and 1 in Massachusetts. **Study 2:** Setting not stated. School simulation lab and online, web-based learning modules. Seventy-one first-year student nurse anesthetists from 8 cohorts randomly assigned to online or simulator groups.	**Study 1** The authors assessed 14,697 TTEs for appropriateness, of which 99% were classifiable using the 2011 AUC. The proportion of rarely appropriate TTEs ordered was measured. **Study 2:** A 25-question multiple-choice pretest covering cardiac anatomy, TEE ultrasonographic windows, and cardiac pathology and a posttest covering the same material.	**Study 1:** The mean proportion of rA TTEs was significantly lower in the intervention versus the control group (8.8% vs. 10.1%; odds ratio [OR]: 0.75; 95% confidence interval [CI]: 0.57 to 0.99; p ¼ 0.039). In physicians who ordered at least 1 TTE per month, there was a significantly lower proportion of rA TTEs in the intervention versus the control group (8.6% vs. 11.1%; OR: 0.76; 95% CI: 0.57 to 0.99; p ¼ 0.047). There was no difference in the TTE ordering volume between the intervention and control groups (mean 77.7 & 89.3 vs. 85.4 & 111.4; p ¼ 0.83) **Study 2:** Posttest scores were significantly higher in both groups, averaging 42.3 (SD = 11.85) in the online group and 69.4 (SD = 17.93) in the simulator group (P < .01).	**Methodological flaws:** **Study 1:** The study only included primary care physicians and cardiologists ordering in ambulatory settings. **Study 2:** Study conducted at one school **Inconsistency:** **Study 1:** None **Study 2:** 8 students were excluded from results for not completing the pre- or post-exam. **Indirectness:** **Study 1:** Cardiologists & primary care physicians **Study 2:** TEE study **Imprecision:** **Study 1:** None **Study 2:** No CI **Publication bias:** **Study 1:** None **Study 2:** None
Design **Study 1:** A randomized control trial. **Study 2:** The design was not stated but appears to be a randomized observational study.				**Implications** **Study 1:** An educational intervention reduced the number of rA TTEs ordered by attending physicians. This may prove to be an effective strategy to improve the use of imaging. **Study 2:** TEE simulation training of nurse anesthesia students, in either modality, can benefit their knowledge and performance in the operating room.	

Anderson, D. R., Blissett, S., O'Sullivan, P., & Qasim, A. (2021). Differences in echocardiography interpretation techniques among trainees and expert readers. *Journal of Echocardiography, 19*(4), 222-232.

Haskins, S. C., Zhao, J., Nejim, J. A., Fields, K., Garvin, S., Dehipawala, S., ... & Tanaka, C. (2017). Evaluation of postgraduates following implementation of a focus assessed transthoracic echocardiography (FATE) training course-a pilot study. *Journal of anesthesia & clinical research*, *8*(9).

Purpose	**Variables**	**Setting/Subjects**	**Measurement and Instruments**	**Results**	**Evidence Quality**
Study 1: To identify different ways experts read TTEs and which technique is effective in teaching novice readers. **Study 2:** To evaluate the feasibility of implementing a focus assessed transthoracic echocardiography (FATE) training course for postgraduate anesthesia providers. Design: **Study 1:** Prospective qualitative case study using concurrent think aloud (CTA) method. Individuals performed a task and spoke out loud what comes to mind as they read the echocardiogram. **Study 2**: Prospective qualitative case study using FATE E-learning method to train individuals in obtaining image from echocardiogram.	**Study 1:** Independent: Accuracy and time taken to read a TTE. Dependent: Level of expertise and prior education, intermediate level echocardiograms. **Study 2**: Independent: anesthesia trainee's ability to obtain echocardiography images. Dependent: Implication of FATE.	**Study 1:** University of California, San Francisco. 3 cardiologists with greater than 10 years of experience reading echocardiograms, 3 fellows at end of their first-year training cardiology who completed 3 months of echo rotations, and 3 fellows in their final year of advanced echocardiography fellowship. **Study 2:** Anesthesia resident fellows from Hospital of Special Surgery and Weill Cornell Medical College.	**Study 1:** Time taken to complete echo report, generated TTE reports analyzed for accuracy by comparing against gold standard of 2 experts. A screen capture program (Snagit) to record the process of how each reader scrolled through echocardiogram, and for each observer to describe their process and order in which they completed the task. **Study 2:** After receiving board approval, 23 anesthesiology residents and fellows were enrolled into a prospective cohort study between October 2014 to March 2015. The participants completed a survey before and after E-learning modules by FATE. The participants were measured by how the participants can form and evaluate an image in 90 seconds, and determine the anatomical presentation, sector optimization, gain adjustment, image sharpness, and interpretational value. The participants were re-evaluated 5 months to follow up with their scores.	**Study 1:** Novices took longer to read and were less accurate compared to advanced and expert groups. Intermediates and experts previewed the entire study first before filling anything out, and aggregate information which novices did not do this. All trainees valued the direct feedback that was undertaking this study and found it very helpful. **Study 2:** Overall the FATE E-learning course had a considerable improvement in total image acquisition of all chambers of the heart and vessels. There was also excellent retention 5 months following training. Implications **Study 1:** This study showed importance of receiving directed feedback while reading a TTE improves training. This study highlights on how there are different ways TTE can be taught but this will begin to develop a systematic approach in training TTE interpretation. **Study 2:** To evaluate effectiveness of echocardiography E-learning	**Methodological flaws:** **Study 1:** Small sample size, single center study, qualitative and subjective. **Study 2:** Small sample size performed in one medical center with qualitative and subjective results. **Inconsistency:** **Study 1:** none Study 2: none **Indirectness:** **Study 1:** Different techniques possibly used to teach novice readers. **Study 2:** None **Imprecision:** **Study 1:** None **Study 2:** None **Publication bias** **Study 1:** none **Study 2:** None

Appendix F

Timeline

June 2022 – Received site approval letter from Echelon for CE module.

June 2023 – Met with representatives from Echelon to submit approved CE module outline

AANA accreditation determination.

September 2023 – ANAA approved CE module for accreditation.

November 2023 – Echelon began development on CE module for publication.

February 2024 – CE module available on Echelon website for review by peer reviewers.

March 2024 – Dissemination of final scholarly project.