Quality Improvement DNP Project: Perioperative ECG Lead Placement

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Notes from the Author

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Abstract

Patients in the perioperative setting are susceptible to incorrect ECG lead placement due to a variety of obstacles such as chest tubes and bandages, as well as surgical sites and positions. Inaccurate and/or inconsistent ECG lead placement has the potential to result in incorrect, missed, or delayed patient diagnosis. This may lead to unnecessary interventions, increased cost of care, and poor patient outcomes. This Doctor of Nursing Practice project assessed the perceived efficacy of a standardized educational aid designed to streamline ECG lead placement and increase consistency among cardiac intensive care unit nurses. A pre-intervention questionnaire, ECG lead reference tool, and voice over presentation were electronically delivered to potential participants who were asked to implement the reference tool ~~i~~n their current practice for two weeks. A post-intervention survey was then electronically delivered to participants for completion, with results collected and analyzed using Qualtrics software. The plan, do, study, act cycle was used to guide this quality improvement project. Participants in the pre- and post-intervention groups consistently reported decreased confidence when placing ECG leads in alternative positions such as lateral or prone. Due to the large discrepancy between the number of pre- and post-intervention participants, no conclusions could be made regarding its impacts on perceptions surrounding ECG lead placement accuracy. This project was helpful in determining nurses' perceived confidence levels when applying ECG leads in various positions. Future recommendations include repeating this project with expansion of potential participants to include nursing assistants who also apply ECG leads in the clinical setting.

Keywords: electrocardiogram, medical error, education, teaching

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Section I. Introduction

Background

When patients present in a clinical setting with chest pain, shortness of breath, or a plethora of other symptoms, an electrocardiogram (ECG) is often ordered to detect cardiac ischemia or abnormalities. While this diagnostic tool is helpful for detecting life threatening conditions, placement of the ECG leads can affect the accuracy of the test results. Studies have documented wide variability of ECG lead placement across health care personnel from a variety of educational levels (Rajaganeshan et al., 2008). Inaccurate placement of ECG leads has the potential to cause harm to patients by exhibiting inaccurate morphology and masking life-threatening waves (Gregory et al., 2019). Heart disease is among the top concerns for the health of Americans. As part of a health improvement campaign within the United States, Healthy People 2030 has recognized the need for improved cardiac diagnostics and timely intervention. Recent objectives include aims to decrease heart failure admissions as well as improved timing of fibrinolytic therapy and percutaneous intervention for heart attack patients (Office of Disease Prevention and Health Promotion, n.d.).

Due to the vulnerability of patients in the perioperative and intensive care setting, it is imperative that ECG results are accurate. During anesthetic procedures and in states of sedation, patients are often unable to verbalize pain, shortness of breath, or many other clinical symptoms associated with cardiac ischemia. Clinicians in the perioperative setting are responsible for accurate placement of ECG leads to ensure results reflect actual pathology to facilitate appropriate treatment and patient safety. In an effort to ensure adequate circulatory function during anesthetic procedures, the American Society of Anesthesiologists (ASA) has implemented standards for ECG monitoring. According to Standard 2.3 on the ASA website, “Every patient

receiving anesthesia shall have the electrocardiogram continuously displayed from the beginning of anesthesia until preparing to leave the anesthetizing location" (ASA, 2020).

Despite advancements in technology and education, correct placement of precordial leads remains the strongest determinant of ECG accuracy (García-Niebla et al., 2009). Incorrect placement of ECG leads, producing inaccurate results, could have potentially life-threatening consequences for the patient as well as financial implications for the health care systems. According to studies performed on patients receiving an ECG, over 10% of ECGs performed may have been interpreted as ischemic events simply due to incorrect placement (Rehman & Rehman, 2020). Procedures performed to manage patients who exhibited an ischemic ECG can be dangerous and costly to the patient. Additionally, unnecessary procedures can delay or interrupt surgery. While incorrect ECG placement is a commonality among all health care settings, this issue places perioperative patients at even greater risk due to their inability to communicate during anesthesia. Additionally, surgical procedures requiring specialized drains, surgical sites, or positioning have the potential to interfere with correct placement of leads. This concern is extended into the intensive care unit where patients undergoing continuous ECG analysis before and after surgery are cared for.

The American Association for Nurse Anesthesiology (AANA) has developed standards to ensure high quality anesthesia care and safety for very patient. In an effort to meet these initiatives, the AANA requires the documentation of an ECG in Standards 5, 6, and 7 (Neft et al., 2013). Along with other monitoring devices, Standard 5 specifically states that while under anesthesia, the CRNA is required to continuously monitor the patient's cardiovascular status with the use of a continuous ECG. While these standards are in place to improve patient safety, the accuracy of the ECG is dependent on the precision of lead placement. At this time, the AANA does not provide specific discussion about the accuracy of lead placement but does place a

particular importance on accurate, complete, and timely documentation of the care provided. Information documented in the patient's chart is considered evidence of the care provided and therefore should only contain accurate information.

Organizational Needs Statement

Healthy People 2030 has placed a particular importance on delivering timely care to patients with cardiac ischemia (Office of Disease Prevention and Health Promotion, n.d.). In an effort to fulfill this initiative, health organizations must prioritize educational tools for perioperative staff to improve accurate placement of ECG leads, decrease time to life saving therapy, decrease health care costs, and improve patient safety. Patients admitted to the intensive care unit often require continuous ECG monitoring before and after surgery. In an effort to deliver timely care, clinical decisions depend on accurate diagnostics to include information derived from ECG data.

This Doctor of Nursing Practice project attempted to improve the perceived accuracy of ECG lead placement by perioperative staff through provision of an educational presentation and mobile reference guide. Currently at the partnering organization there are no standards for ECG lead placement outside of instructions provided by the equipment manufacturer. Despite these instructions, improper and inaccurate ECG lead placement continues to negatively affect health care systems and patients across the globe. Manufacturer instructions are not specific to the patient's size, age, gender, body type, or even the proposed surgical procedure. According to this project's chair, education and safety are among the top core values implemented within the multiple hospitals operated by this organization (T. Chabo, personal communication, September 12, 2022). As the surgical site for almost 50,000 inpatient surgeries annually, this large organization has an obligation to educate staff members about proper ECG placement to ensure perioperative patient safety.

Problem Statement

Inaccurate and/or inconsistent ECG lead placement in the perioperative setting has the potential to result in incorrect, missed, or delayed patient diagnosis. This may lead to unnecessary interventions, increased cost of care, and poor patient outcomes.

Purpose Statement

This Doctor of Nursing Practice project assessed the perceived efficacy of a standardized educational aid designed to streamline ECG lead placement and increase consistency among Cardiac Intensive Care Unit nurses in the perioperative setting. ECG lead placement education included standard, 6-lead placement, 12-lead placement, and alternative placement required for varying surgical procedures and positioning.

Section II. Evidence

Description of Search Strategies

While there is a plethora of published articles surrounding the use of an ECG, limited research was identified regarding the accuracy of lead placement by perioperative staff. In an attempt to identify contributing factors that potentially cause inaccurate lead placement, as well as possible solutions to this problem, searches of existing scholarly literature were conducted using Cumulative Index to Nursing and Allied Health Literature (CINAHL), PubMed, and Google Scholar. For the initial search, concepts such as ECG lead, accuracy/medical error, and education were entered for each database or search engine. CINAHL was searched using the medical headings electrocardiography or electrodes; health care errors, treatment errors, diagnostic errors or measurement error; and education. PubMed was searched using the medical subject heading (MeSH) terms electrocardiography, medical error, artifact, education, and teaching. The Google Scholar search was performed using the concepts ECG lead, medical error, and education. Refer to Appendix A for a list of topics and terms used for each search engine. A limit was applied to each database or search engine to only provide articles published between the years 2017 until 2023. Terms were modified for each search engine and database to maximize return of applicable literature. See Appendix B for further details on search results.

Upon completion of each search, results were screened based on title, with focus placed on those pertaining to the placement of ECG leads. In an effort to obtain additional research and information, related and referenced articles were also evaluated for applicable information. A thorough search of professional organizations including the AANA and ASA was also conducted. Exclusion criteria included titles pertaining to the interpretation of ECG and non-human subjects studied. After additional review of the results, eight articles were identified as reliable with quality resources based on relevance and level of evidence according to Melnyk and

Fineout-Overholt (2019). The identified articles provided evidence-based research and guidelines about standards of care surrounding ECG lead placement, common errors, and potential factors that could lead to incorrect ECG lead placement. Evaluation of full text revealed one quasi-experimental study (Level II), one qualitative study (Level III), one quality improvement (QI) study (Level IV), one systematic review and metanalysis (Level I), three quantitative questionnaire studies (Level VI), and one expert opinion that published a list of standard guidelines for ECG during anesthesia (Level VII). See Appendix C for literature matrix, levels of evidence, and summary of findings. Since this project aimed to assess the perceived efficacy of educational material on correct ECG lead placement, importance was placed on articles that listed educational shortfalls that could mitigate potential error.

Selected Literature Synthesis

The focus of this literature review was to highlight the importance of ECG lead placement and the detrimental effects of incorrect placement of ECG leads by clinicians. Topics addressed included indications for an ECG, placement of leads, effects of incorrect ECG placement, potentially harmful interventions from incorrect ECG results, and the benefits of educational interventions. Points of focus included the importance of correct ECG lead placement, the harmful effects of incorrect placement, the benefits of education, and effects on patient safety in the healthcare system.

Accurate diagnostic results are the backbone of effective treatment plans. Organizations such as the ASA have determined that ECG monitoring should be a standard of care. According to Standard 2.3, “Every patient receiving anesthesia shall have the electrocardiogram continuously displayed from the beginning of anesthesia until preparing to leave the anesthetizing location” (ASA, 2020). One of the most frequently used diagnostic tools across the world is the ECG. While this tool is used to interpret patient status and identify cardiac issues, it

is also prone to human error. For decades, there have been documented errors in the placement of ECG leads across a variety of educational levels (Rajaganeshan et al., 2008). Human error continues to impede the accuracy of diagnostic results and has the potential to mask life threatening ECG waves indicating events which could precipitate lethal outcomes (Gregory et al, 2019).

Indications for ECG

Establishing the indications for an ECG helps describe the best use of the technology, along with possible implications of improper use. An ECG is defined by Medani et al. (2017) as "…a recording of the magnitude and direction of the electrical current generated during depolarisation and repolarisation of the heart, by external electrodes placed in standard positions on the body surface" (p. 50). When establishing the importance of ECG technology, Rajaganeshan et al. (2008) stated that symptoms such as angina secondary to cardiac ischemia are responsible for thousands of daily hospital admissions. Diseases affecting cardiac vasculature are of the utmost importance since distal perfusion is directly related to cardiac blood flow and function. Similarly, Giannetta et al. (2020) offer that the ECG is the most commonly used diagnostic tool for measuring electrical activity of the heart to aid in determining the extent of cardiac disease. Work by Kania et al. (2014) described ECG utility to detect cardiac disease and coronary artery disease as using correctly placed electrodes on the skin that measure the conduction of electrical activity through the cardiac muscle. While the ECG is not the most specific or sensitive diagnostic tool for the detection of cardiac ischemia and other potential pathology, it is the most widely used and cost-effective cardiac-specific diagnostic tool (Rjoob et al., 2020).

Placement of Leads

Proper placement of ECG leads is essential for accurate results and to make appropriate treatment plans. According to studies conducted by Rajaganeshan et al. (2008), there are differences in accuracy of lead placement among educational levels. While one would assume the most educated clinicians would display the most accurate placement, these researchers found the most accurate placement was performed by cardiac technicians, followed by nurses, physicians, and cardiologists. The researchers also found leads V1 and V2 were frequently incorrectly placed across all educational levels. When subjects were asked to mark the V5 and V6 leads from the lateral view, frequent mistakes were noted due to uncertainty about correct rib spaces. Though dated, results drawn from this study are applicable today due to the unchanged structure of healthcare hierarchy and responsibilities. Gregory et al. (2019) noted in a study among a small group of paramedics that over 94% of participants displayed incorrect placement of leads.

Medani et al. (2017) noted inaccuracies of lead placement by doctors, nurses, and cardiac technicians. Unlike other studies, the researchers used radar plotting to chart the accuracy of placement and analyzed the accuracy of lead placement before and after an educational intervention. The results of the pre-intervention were similar to findings by Rajaganeshan et al. (2008), with both noting leads V1 and V2 having the most inaccurate placement. In contrast to the findings of Rajaganeshan et al., however, Medani et al. (2017) specifically noted changes in accuracy after educating the participants on correct lead placement and identified significant improvement in accuracy of lead placement among all educational levels.

Giannetta et al. (2020) used a cross-sectional questionnaire to assess 484 nurses and nursing students concerning sociodemographic/professional characteristics, theoretical knowledge, and level of accuracy with ECG lead placement. Collection of sociodemographic and

professional characteristics revealed that education among nursing students and practicing nurses was a significant contributor to accurate placement of leads and clinical knowledge. Accuracy of lead placement was much higher than theoretical knowledge of correct lead placement and the impact on morphology. The results of the study supported a lack of adequate education among nurses and nursing students as it pertains to ECG knowledge.

Kania et al. (2014) concluded that V1 and V2 leads are often placed substantially higher than the optimal positioning. While Kania et al. noted similarities surrounding lead placement, they also documented the changes in electrical current and wave morphology during misplacement. In contrast to other studies, Kania et al. provided an in-depth look at which leads are more susceptible to incorrect changes in morphology, along with clinical implications.

In summary, incorrect placement of the precordial leads was a common finding across multiple studies (Giannetta et al., 2020; Gregory et al., 2019; Kania et al., 2014; Medani, et al., 2017; Rajaganeshan et al., 2008). Of particular note, Gregory et al (2019) indicated that while even 1 centimeter displacement of any lead can cause changes in morphology, 2 centimeters of displacement led to a more substantial degree of change, with leads V2 and V3 found to be the most sensitive leads to any degree of displacement while leads V5 and V6 were least sensitive to displacement.

Effects of Incorrect Placement

The effects of incorrect ECG lead placement can pose a significant risk for patients. According to Rajaganeshan et al. (2008), inaccurate lead placement creates potential risk in two ways. If leads are placed improperly and display an inaccurate ECG, patients could receive potentially unnecessary and/or harmful treatments such as antiplatelet therapy, antithrombotic agents, or even cardiac catheterization. While these treatments are useful in the event of real cardiac ischemia, each intervention has the risk of harm and potential death. Secondly, in the

event of real cardiac ischemia, a doctor could fail to prescribe the appropriate treatment due to incorrect morphology of waveforms that appear as artifact or insufficient variation in electrical waves. Rjoob et al. (2020) indicated potential harm of improper placement by masking or falsely diagnosing conditions such as anterior infarction, ventricular hypertrophy, ischemia, or Brugada syndrome.

According to Medani et al. (2017), improper placement of precordial leads can cause real harm to patients, including the misdiagnosis of anteroseptal infarct. The authors noted that significant displacement of leads caused both false positive and false negative ischemia-related wave morphology. Kania et al. (2014) suggested that a 2 centimeter displacement of the precordial leads can cause R wave morphology and uncertainty about clinical relevance. Kania et al. (2014) stated, "whether observed changes have significant effect on clinical diagnosis still remains under question and need clinically oriented studies" (p. 117).

While patient safety and positive outcomes should remain at the forefront of treatment priorities, it is impossible to ignore the financial burden that comes with unneeded treatment plans following diagnostic errors. When evaluating the results of other similar ECG studies, Rehman & Rehman (2020) noted the average incidence of inaccurate ECG placement indicated by poor R wave progression was just over 16%. When errors such as incorrect placement of precordial leads produce results consistent with a myocardial infarction, the price of the interventions can become overwhelming. Medical errors and misdiagnosis due to inaccurate ECG lead placement have the potential to cost the health care system over 3.2 billion dollars annually.

Improving ECG Lead Placement

Supplemental education utilized by health care providers who frequently apply ECG leads have been shown to drastically improve lead placement accuracy. As previously noted, a

study conducted by Medani et al, (2017), researchers described that before education on the correct placement of ECG leads, frequent errors were noted among nurses, doctors, and cardiac technicians. Using a pre- and post-test design to assess the impact of an educational program, these authors noted significant improvement post-intervention.

Conclusion

The ECG is an essential diagnostic tool for quick and cost-effective diagnosis of cardiac related problems, but the results of this tool are only useful in relation to the accuracy of electrode placement. As noted in this synthesis, improper placement of ECG leads was frequently noted among all educational and professional levels (Gianetta et al., 2009; Gregory et al., 2019; Medani et al., 2019; Rajaganeshan et al., 2008; Rehman & Rehman, 2020; Rjoob et al., 2020). Improper lead placement has been shown to mask life threatening conditions or even provide false positives in the absence of life-threatening conditions (Rehman & Rehman, 2020; Kania et al., 2014). Failure to address improper ECG lead placement has the potential to cause patient harm as well as significant financial stress on the health care system nationwide (Rehman & Rehman, 2020). The incidence of improper ECG lead placement can be mitigated with the use of frequent education and continuous QI activities (Medani et al., 2017).

Project Framework

The model for improvement using the plan-do-study-act (PDSA) cycle served as a structured guide for this QI project (Institute for Healthcare Improvement, 2022). Identification of a problem guides the initial trajectory of the PDSA cycle. Once a problem is identified, an intervention and planned method of objective measurement is established. Implementation of the proposed intervention is carried out and the objective information produced is collected for further evaluation. Acting on the information collected is essential for improving upon weaknesses of the intervention and project processes as well as highlighting any strengths. The

PDSA model is a continuous cycle that aims to not only organize a current project, but to also provide insight on opportunities for improvement among future studies.

Implementation of this model served to organize and streamline a plan to assess the perceived accuracy of ECG lead placement by nurses in the organization's cardiac intensive care unit (CICU) who often care for perioperative patients. Planning began with reviewing evidence-based literature in search of contributing factors and potential educational interventions for inaccurate ECG lead placement. Collaboration among group members and the project chair produced pre- and post-intervention questionnaires, an educational presentation with voice-over instruction, and a PDF reference document addressing correct lead placement. The "do" stage of this project was conducted independently by the primary investigator, a Student Registered Nurse Anesthetist (SRNA), over a two-week period. This phase began when the pre-intervention questionnaire, voice-over presentation, and PDF materials were delivered electronically to participants. Results of this initial cycle were collected via the post-intervention survey used to assess the perceived efficacy of the educational material in regard to accuracy of ECG lead placement during the perioperative period. Qualtrics software (Qualtrics.com) was used to develop questionnaires and collect results of the project. The results were studied and evaluated for potential strengths and weaknesses while also screening for opportunities to improve project strategies in the future in the "study" phase. The "act" phase included presenting the project findings to other students, nurse anesthesia program mentors, and organizational leaders. Insight was provided on how the conclusions made could impact patient care as well as lead future PDSA models.

Ethical Considerations and Protection of Human Subjects

Nurses who volunteered to participate in this project had the potential to benefit from an educational tool addressing proper ECG lead placement. The presentation and educational tool

were both based upon currently accepted standards of care and electronically delivered through a secure virtual link. The pre- and post-surveys were completed online, with responses remaining confidential. Identified risks for participants included a small time requirement to review materials and potential for some stress from learning new material. This project did not involve patients, patient results, or patient information. Prior to embarking on this QI project, Collaborative Institutional Training Initiative (CITI) modules were completed by the primary investigator to ensure understanding of the possible ethical and legal implications associated with research and quality improvement projects (https://about.citiprogram.org/).

Initial approval for this project was obtained through a screening review set up by the East Carolina University College of Nursing (ECU CON) and the University and Medical Center Institutional Research Board (UMCIRB). It was determined the project was QI in nature and thus exempt from full IRB review. Additional facility approval was obtained through the research office of the partnering organization in conjunction with the UMCIRB. Facility approval was verified and documented with the signature of an on-site representative agreeing to support data collection in the specific clinical area (see Appendix D).

Section III. Project Design

Project Setting

The setting of this QI project was the cardiac intensive care unit (CICU) of a large regional hospital in North Carolina. This unit contains 24 beds which are designated for critically ill medical and cardiac patients. Upon stabilization, surgical intervention is often utilized as a treatment option for conditions for which safe resolution extends beyond simple medical management. This QI project focused on the accuracy of ECG lead placement by CICU nurses working in a large regional hospital. Frequent lead placement by nurses in the CICU allowed for the educational tool to be utilized daily.

Project Population

Nurses working in the CICU were the population of focus for this project. At the time of this project implementation, 72 nurses were actively employed on this unit. Due to the variability of staff schedules, face-to-face intervention and education for all participants was not feasible. This scheduling barrier was mitigated with the use of an electronically delivered educational presentation and PDF reference tool (see Appendix E). Potential barriers within this population included resistance to change, time required to use the reference tool, and lack of participation.

Project Team

The project team for this QI project consisted of the primary investigator, an SRNA, as the team leader, and three fellow SRNAs working within the same project topic. Together, this team of SRNAs collaborated on the development of the project's purpose, intervention, and survey questions. Independently, this author implemented the intervention, gathered data, analyzed data, and shared the findings. Additionally, this author obtained a signature of approval from the unit representative for permission to implement this project in the CICU. The project chair was a CRNA faculty member who also served as the clinical contact. As the project chair

and clinical contact, this CRNA assisted with obtaining participants and designing the project intervention. An additional CRNA faculty member, the program director, aided with the planning, organization, and professional design of the project. The course director, a non-CRNA faculty member, provided guidance throughout the planning, implementation, evaluation, and presentation of the project.

Methods and Measurement

This QI project aimed at assessing the perceived efficacy of a standardized educational aid designed to streamline ECG lead placement and increase consistency of placement by CICU nurses caring for patients in the perioperative setting. An email was sent to potential participants with a Qualtrics link to a pre-intervention survey that assessed their perceptions of ECG lead placement. A voice-over presentation and a PDF reference guide for proper ECG lead placement were attached to this same email for review and use by participants after completion of the pre-survey. A copy of the educational material can be referenced in Appendix E. Electronic communication via e-mail with participants is noted in Appendix F.

After a two-week implementation period, a post-intervention survey link was emailed to the potential participants, and responses were collected using Qualtrics software (qualtrics.com). See Appendix G for surveys. To provide confidentiality, the names of participants were not documented or shared. The outcome of the project was aimed at assessing participants' perceived efficacy of the educational material presented on the accuracy of ECG lead placement in the CICU and perioperative period.

The IHI model for improvement, using the PDSA cycle, served as the framework for this QI project (IHI, 2022). During the planning phase, a literature search was performed to collect information about the incidence, impact, and contributing factors leading to inaccurate ECG lead placement. Group meetings were held monthly with the project chair and other SRNA group

members to discuss common trends and potential treatments identified within current, published research. A voice-over presentation and mobile PDF reference guide were developed as the educational intervention. Pre- and post-intervention surveys were developed and placed in a mobile delivery format using Qualtrics survey software. Approval for the project was obtained through the unit and organizational representatives. Potential participants were identified with the help of the project chair and the assistance of the CICU unit manager.

The interventions for this QI project were implemented during the "do" phase. A pre-intervention survey, voice-over presentation, and PDF reference guide were emailed to all nurses on the CICU. Upon completion of the pre-intervention survey, participants were instructed to view the voice-over presentation and PDF reference guide attached to the corresponding email. Over the following two-week period, participants were asked to voluntarily implement the information provided into their daily ECG lead placement practice. Upon completion of the two-week implementation period, participants were asked to complete the post-intervention survey designed to assess their perceived efficacy of the educational intervention. Surveys dispersed to participants were comprised primarily of Likert scale questions pertaining to comfort levels in placing ECG leads across a variety of situations and patient positions.

Results were collected and analyzed as part of the "study" and "act" phases. Trends and prevalence of common answers were noted among the responses of participants. Excel software was used to process the data collected and create visuals. After thorough evaluation, the results were interpreted and used to provide suggestions for future implementation strategies. As part of this DNP project, results were displayed as an electronic project poster and presented to faculty and students of the nurse anesthesia program with invitations also sent to participants. A description of the findings can be found in the following sections of this DNP paper.

Section IV. Results and Findings

Results

This Doctor of Nursing Practice project assessed the perceived efficacy of a standardized educational aid designed to streamline ECG lead placement and increase consistency among CICU nurses in the perioperative setting. ECG lead placement education included standard 6-lead placement and alternative placement required for varying surgical procedures and positioning. After meeting and planning with the nurse manager, it was decided that participants would be more apt to complete the surveys if they were forwarded by the nurse manager. The pre-intervention survey link was shared electronically with the nurse manager of CICU on April 9, 2023. Along with the pre-intervention survey, links to the educational PowerPoint presentation with voice-over and the ECG lead reference tool were included. On April 12th, the pre-intervention survey was then sent by the nurse manager to the 72 nurses employed on the unit. Additionally, 12 paper copies of the reference tool were placed in the break room. Sixteen pre-survey responses were received between April 15th and May 3rd, resulting in a 22.2% response rate.

Data collection and implementation of the ECG lead reference tool began on April 12th and continued through April 26th. The original dates for implementation were slightly modified to accommodate for the delay in delivery to participants and low rate of responses. Upon completion of the data collection period, the post-intervention survey link was shared electronically with the nurse manager. Four post-intervention responses were received between April 26th and 28th, a 5.5% response rate. Data was collected using Qualtrics software and results were analyzed using Excel. A thank you letter was then electronically delivered to the nurse manager and participants to thank them for their participation in this QI project. It was noted that

after delivery of the post-intervention survey and thank you letter, participants continued to complete the pre-intervention survey (until May 3rd), but no additional responses were recorded for the post-intervention survey.

During the implementation phase of this project, three face-to-face visits were made to the unit to address any questions or concerns regarding the educational presentation or reference tool. During the last visit it was noted that a similar reference tool had already been implemented in prior years. Prior to the implementation of this QI project, nurses and nurse assistants had been provided a laminated, badge-sized reference tool which displayed a picture of correct lead placement as well as a chart which annotated the location of each lead. The tool included 3-lead, 6-lead, and 12-lead ECG placement. Education about alternative lead placement was not included on the tool introduced prior to this QI project. Though nurses are primarily responsible for performing 6-lead ECGs on this unit, nursing assistants working in CICU have been trained on, and are the primary ones performing, 12-lead ECGs with the portable machines.

Data Presentation

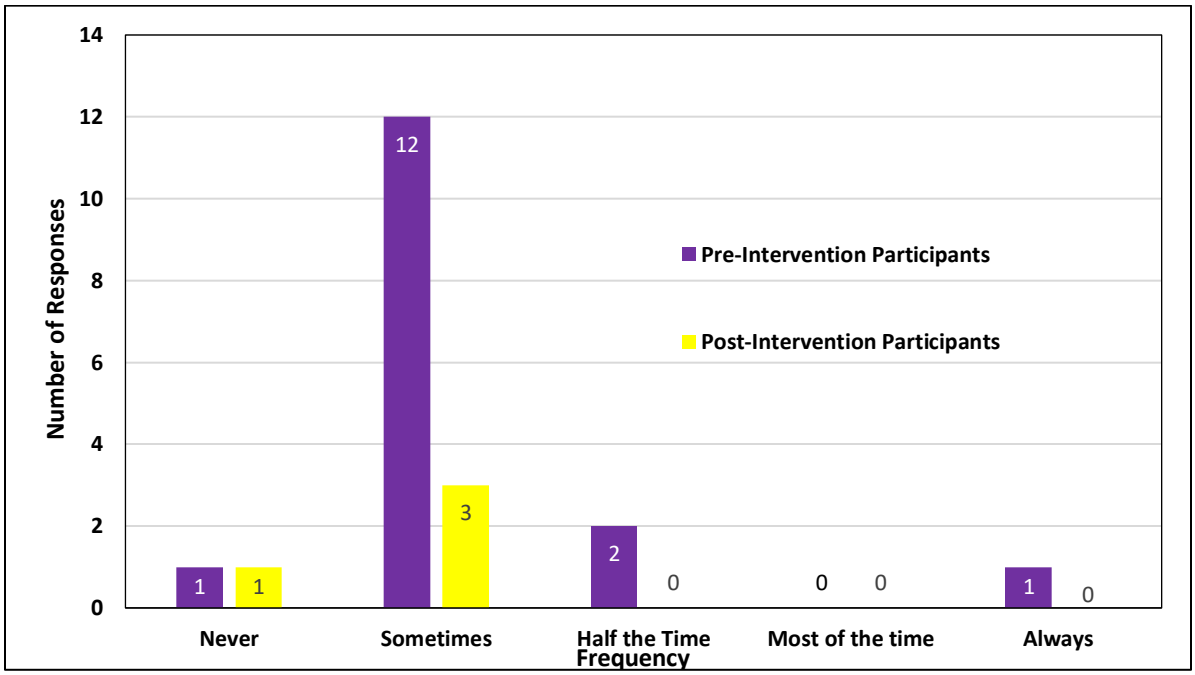
The first question on the pre intervention survey was, “Did you receive any formal training in ECG lead placement as part of the onboarding process for your discipline?” Thirteen of the 16 participants responded yes, while only three responded no. According to these responses, it appears that nurses on the CICU at this large regional hospital do receive formal educational training on ECG lead placement. The following question asked, “How often do you follow a standardized method for applying ECG leads?” Almost all participants responded always or almost always, with only three of the 16 participants responding that they use a standardized method less than most of the time. The question “How confident do you feel placing ECG leads accurately in the following standard and alternative positions?” was asked to

assess the participants' confidence level for supine, lateral, and prone positions. For supine, 12 participants responded as "very confident," while four responded as "somewhat confident." When asked about the prone position, five responded "very confident," eight responded as "somewhat confident," two responded as "not very confident," and one responded as "neutral." When asked about lateral position, four responded as "very confident," eight responded as "somewhat confident," three responded as "neutral," and one responded as "not at all confident."

When asked, "How often do you experience artifact or incorrect morphology with your current practice?", most participants responded "sometimes" (see Figure 1). When asked, "How often do you adjust ECG lead placement for body habitus, position, dressings etc., to obtain an acceptable ECG tracing?" responses varied from "never" to "always" (see Figure 2).

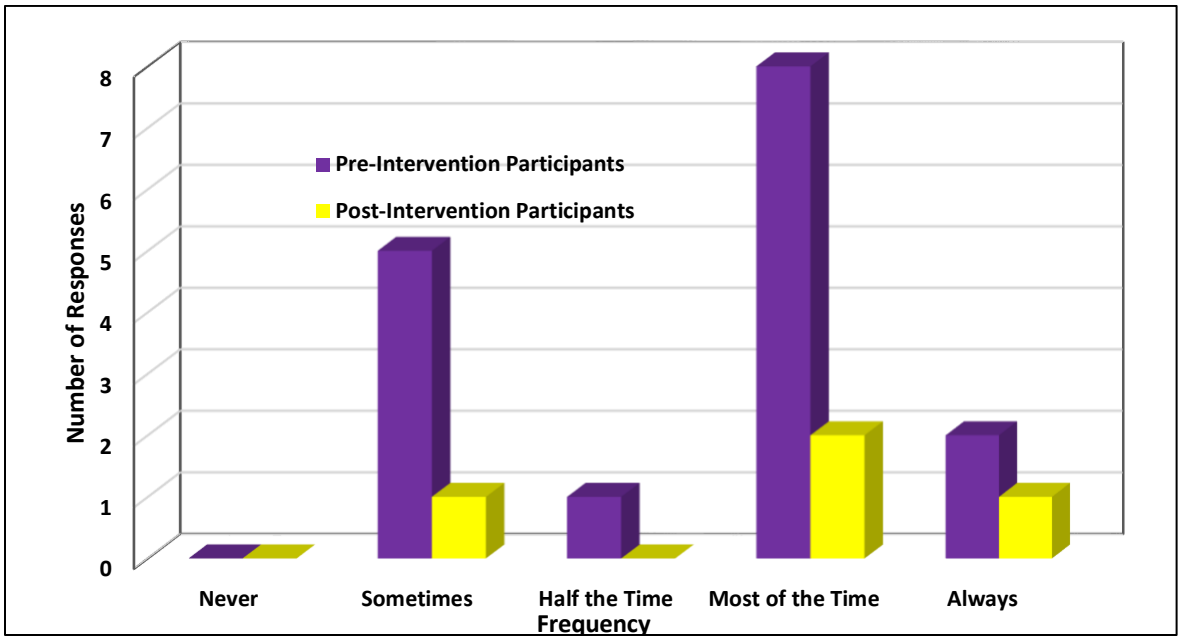
Figure 1

Frequency of Artifact or Incorrect Morphology



Note. Pre-intervention n = 16. Post-intervention n = 4.

Figure 2
Adjustment of ECG Leads



Note. Survey Question: "How often do you adjust ECG lead placement for body habitus, position, dressings, poor wave forms etc. to achieve an acceptable ECG tracing?" Pre-intervention n = 16. Post-intervention n = 4.

When asked, "How often do you receive patients with inaccurate ECG lead placement?" one participant responded, "never," six "sometimes," seven "about half the time," and two "most of the time." When asked, "Do you believe the quality of patient care could be improved with more accurate ECG lead placement?" two responded "might or might not," 11 responded "probably yes," and three "definitely yes." When asked "What are any other obstacles to accurate ECG lead placemen that you have observed?" one participant responded, "When patients have other things on their torso, such as defib pads, Arctic Sun pads, etc.," another "Defibrillator pad placement," one "Moved by other team members," one "multiple devices,

increased WOB," and two "none" or "no other obstacles observed." Ten of the participants chose not to respond to this question.

The post-intervention questions sought to assess the participants' perceptions about the intervention tool and its clinical application for proper ECG lead placement. Unfortunately, there were significantly fewer participants for the post-intervention survey as compared to the pre-intervention survey. While the pre-intervention survey had 16 participant responses, the post-intervention survey had only four. The following question assessed confidence level in various positions by asking "After using the ECG tool, how confident do you now feel placing ECG leads?" Regarding the supine position, all participants responded they were "very confident." For prone positioning, two responded "somewhat confident," and two "very confident." For lateral positioning, all responded they were "somewhat confident."

When asked, "After using the ECG placement tool, how often do you experience artifact or incorrect morphology?" the majority responded "sometimes" (see Figure 1). When asked, "After using the ECG placement tool, how often do you adjust ECG lead placement for body habitus, position, dressings etc., to obtain an acceptable ECG tracing?" responses varied from "sometimes" to "always" (see Figure 2). When asked, "How likely are you to continue using the ECG placement tool when applying ECG leads?" one participant responded they were "somewhat likely," while three responded "extremely likely." When the participants were asked if they thought the tool was easily accessible, all responded "strongly agree." When asked, "How often did you use the ECG placement tool in your practice since receiving it?" one responded "never," one "sometimes," one "most of the time," and one "always." When asked about the amount of additional time needed to reference the tool provided, three participants responded "less than 1 minute," and one "1-2 minutes."

When participants were asked if the ECG placement tool improved the quality of care delivered to patients, two responded “somewhat agree,” one “neither agree nor disagree,” and one “strongly agree.” When asked “After using this reference tool and participating in this QI project, do you feel an annual continuing education module on ECG lead placement would improve patient care?” two participants responded “maybe” and two “yes.” Finally, the post intervention survey asked if there were any feedback or suggestions that had not been addressed. No responses were provided.

While there was a large difference in the number of participants for each survey, most of pre- and post-intervention participants responded that they only experience artifact or incorrect morphology sometimes (see Figure 1). It was noted that, compared to the post-intervention responses, a larger proportion of pre-intervention responses indicated artifact or incorrect morphology was present, with responses of “half the time” or “always.”

For the question “How often do you adjust ECG lead placement for body habitus, position, dressings, poor wave forms etc. to achieve an acceptable ECG tracing?” there was a large difference in the total number of participants but the ratio of responses for the pre- and post-intervention survey was similar (see Figure 2). The majority of participants for each survey responded that adjustment of the ECG leads is required “most of the time.” The pre-intervention responses displayed an increased proportion of participants responding “sometimes”, while the post-intervention participants had an equal proportion of responses for “sometimes” and “always.”

Analysis

Due to the sizable difference in the number of pre- and post-intervention participants, a clear inference could not be drawn regarding the perceived efficacy of the ECG lead reference

tool. The pre-intervention survey included 16 participants while the post intervention survey only included four. Despite multiple in-person visits to the unit, participation numbers remained low for the pre-intervention responses and even lower for the post-intervention responses. The data fails to display any improvements in comfort levels across various positions, improvements in the presence of artifact, or incorrect morphology.

Despite differences in the number of participants between pre- and post-intervention surveys, the post-intervention survey could provide some insight into the overall opinion of the reference tool and the potential impact on quality of patient care. Three out of four post-intervention participants responded that the tool would improve the quality of patient care, and all agreed it took less than 2 minutes to reference and was easily accessible. With the potential for improvements in quality of patient care and short duration of time required to reference, this tool has the potential to positively impact the accuracy of ECG lead placement while also avoiding the burden of added time.

Section V. Implications

Financial and Nonfinancial Analysis

This project has the potential to provide financial benefits for the patient, unit, hospital, and health care system. Since there is already a similar reference tool in place, the cost to also include placement in alternative positions or right-sided ECG is essentially nothing. Improving the accuracy of ECG lead placement could provide significant healthcare cost benefits, as inaccurate ECG results could lead to more costly tests, interventions, medications, and increased hospital length of stay. Increases in all these aspects would directly impact hospital costs for staff compensation, as increased numbers of procedures, interventions, and greater length of stay all equate to increased spending on staffing. To implement this intervention, no additional expenses are expected in regard to stocking, supplies, changes to workflows, or changes to the electronic health record.

As discussed earlier, inaccurate placement of ECG leads has the potential to produce results that may appear life threatening. An ECG costs around $200 at the partnering organization. The results, if inaccurate, can lead to inappropriate diagnoses and treatments, as well as additional financial costs. During a suspected coronary occlusion, it is common for providers to order a coronary catheterization. Procedures such as this can cost over $8400 while also increasing the risk of patient injury and potential for adverse outcomes and lawsuits. Lawsuits surrounding coronary catheterization and provider error have been shown to end in settlements over $2.6 million U.S. dollars (Walter, 2023). In addition to procedural costs and potential lawsuits, the average cost per day for an intensive care unit bed in the United States is over $16,000 (Kramer et al., 2017).

Implementation of this project had the potential to directly impact the health and finances of both patients and the healthcare system. Minor modification to the currently used reference has the potential to produce major improvement. The cost of modification is nearly zero, while the cost of the negative implications associated with inaccurate ECG results has the potential to add up to millions of dollars.

Implications of Project

Accurate ECG lead placement is imperative when gathering clinical evidence to make a diagnosis or to implement continuous monitoring. Failure to accurately place ECG leads has the potential to produce an inaccurate ECG, which could potentially lead to delayed or incorrect diagnoses, including masking of life-threatening wave forms (Kania et al., 2014; Rehman & Rehman, 2020). Patients in the perioperative setting are among the many patient populations at risk of incorrect ECG lead placement. According to Standard 2.3 published by the ASA, "Every patient receiving anesthesia shall have the electrocardiogram continuously displayed from the beginning of anesthesia until preparing to leave the anesthetizing location" (2020). Additionally, the AANA Standard 9 states that the anesthesia provider will "monitor, evaluate, and document the patient's physiologic condition as appropriate for the procedure and anesthetic technique. When a physiological monitoring device is used, variable pitch and threshold alarms are turned on and audible" (Neft et al., 2013). The AANA continues to reaffirm their stance on this topic by requiring documentation of an ECG in Standards 5, 6, and 7. Along with other monitoring devices, Standard 5 specifically states that while under anesthesia, the CRNA is required to continuously monitor the patient's cardiovascular status with the use of a continuous ECG.

The purpose of this DNP project was to assess the perceived efficacy of a standardized educational aid designed to streamline ECG lead placement and increase consistency among

CICU nurses in the perioperative setting. ECG lead placement education included standard, 6-lead placement and alternative placement required for varying surgical procedures and positioning. Based on the findings, expansion upon this QI project could provide benefits to the nurses and patients in the CICU. When asked about ECG lead placement in various positions, participants' responses indicated that there were varying levels of comfort associated with each position. Most participants reported a high level of comfort in the supine position, but when asked about lead placement in lateral and prone position the average level of confidence decreased dramatically. Additionally, on both the pre- and post-intervention surveys, participants reported the presence of incorrect morphology after lead placement.

The results of this project were consistent with the information found during literature review. Human error continues to contaminate the accuracy of diagnostic results to include the ECG analysis and has the potential to contribute to poor patient outcomes (Gregory et al, 2019).While this QI project did not include an audit of participants' ECG lead placement, the presence of artifact and incorrect morphology in addition to decreased confidence level among those placing the leads indicated that there is some degree of incorrect placement. The results reviewed from this project are consistent with those noted by Medani et al. (2017), concluding that inaccuracies in ECG lead placement are present among all levels of clinical staff.

Patients and hospital systems would all benefit from improving the accuracy of ECG lead placement. Patients would receive improved quality of care and cost reduction while potentially avoiding risky procedures such as cardiac catheterization. Hospital systems would also see a cost reduction and increased financial return due to increased reimbursement and decreased incidence of legal cases.

Sustainability

The clinical use of ECGs is not limited to the CICU and therefore this QI project has the potential to benefit multiple units across the organization. Future QI projects focusing on the perceived efficacy of an ECG reference tool would provide a low-cost initiative to improve the accuracy of ECG lead placement while also decreasing the financial burden that accompanies inaccurate ECG results. The costs associated with implementation of the project are essentially zero due to the electronic delivery of the educational presentation, reference tool, and survey questions.

Noting the limited participation in this project, an incentive program could potentially increase the number of participants by rewarding those who complete both the pre- and post-intervention survey. Despite several face-to-face visits and meetings with members of the unit leadership, potential participants did not appear to be interested in the project or its potential benefits. One reason for this could be linked to the laminated, badge-sized reference tool that is currently in use on the unit. Along with this, it was discovered during this QI project that the nursing assistants on the unit are primarily responsible for performing the 12-lead ECG, while the nurses and nursing assistants share the responsibility of performing lead placement for the 6-lead continuous ECG. The population of interest for this project was CICU nurses, but to implement a sustainable program it would be important to also include nursing assistants.

Implementation of this intervention within the organization would be cost-effective and has the potential to provide tangible safety and financial benefits. Reference tools provide real-time feedback on current practice guidelines for ECG placement and could potentially prevent an inaccurate ECG result. Avoiding inaccurate ECG results could potentially decrease the incidence

of costly and unnecessary procedures, such as cardiac catheterization, which are also associated with risk and liability.

Incorporation of the reference tool within the organization is sustainable due to the benefits provided to the patients, staff, and facility. The benefits obtained using the tool extend far beyond financial gain and liability concerns. Decreased length of stay, improved patient outcomes, and patient satisfaction are among the numerous potential benefits associated with implementation of the tool. Post-intervention participants consistently reported that referencing the tool did not take an exaggerated amount of time which would support greater likelihood of use in daily practice. To encourage the use of this tool, the organization could additionally attach a laminated copy to the ECG machine or have a copy on the wall of each patient's room. This low-cost initiative could potentially improve ECG accuracy and patient outcomes without serving as a financial burden.

Dissemination Plan

The process, intervention information, and results obtained throughout this project were displayed on a poster and presented to an audience made up of ECU nurse anesthesia program faculty and SRNAs. An invitation was extended to additional students and project participants to attend the presentation online. East Carolina University's digital repository, The Scholarship, contains the final versions of this project paper as well as the project poster presented.

Section VI. Conclusion

Limitations

The low number of participants and inconsistent number of responses were major limitations for this project. As stated previously, the pre-intervention survey received 16 responses while the post-intervention survey only received four responses. Due to this inconsistency, it is difficult to draw conclusions about the impact of the intervention in regard to multiple aspects of proper ECG placement and nurse comfort with accurately identifying proper sites for standard and alternative electrode locations. An increased number of participants and equal number of both pre- and post-survey responses may have provided insight on whether or not this tool increased nursing staff comfort level with ECG lead placement in various patient positions. Along with monitoring trends in comfort levels, more participation could have potentially helped reveal any impact of the tool had on prevalence of artifact and inaccurate morphology.

In addition to lack of participation, the dates of implementation for this project needed to be extended due to two factors. When the pre-intervention survey link was sent to the nurse manager, there was a three-day delay in delivery of the link to the potential participants. An extended implementation time was utilized to decrease risk of low participation based on short duration of opportunity. A second factor supporting extension of the implementation period was overall lack of participation. Unfortunately, the number of responses to both the pre- and post-intervention survey remained low despite investigator visits to the unit, meetings with the nurse manager, and extension of the implementation period.

Barriers to this project included nurses that worked night shift, weekend option, part-time, and/or were absent due to vacation or personal matters. To account for this, electronic

delivery of the educational material and reference tool was utilized and sent by the unit's nursing management. Unfortunately, nurses who were on vacation or absent for the entire duration of the project were unable to implement the reference tool and likely did not participate in the project.

Recommendations for Future Implementation and/or Additional Study

Future extension of this QI project would be improved with a larger pool of potential participants to include other staff such as nursing assistants. Inclusion of these staff members would increase the number of participants and improve the quality of results. Failure to include these nursing assistants as potential participants would also skew the accuracy of results since the majority of the 12-lead ECGs performed on the unit were performed by nursing assistants.

To minimize barriers surrounding the implementation of the reference tool, printed copies of the tool could be placed in the breakroom for participants who are unable or unwilling to access the electronic PDF reference tool. In addition to these efforts, a laminated copy of the reference tool could also be attached to the mobile ECG machine and bedside monitors. Providing laminated copies kept within easy reach would provide multiple benefits such as ease of access and easy sterilization between patients. Attaching the laminated reference tool to the ECG machines and/or monitors could allow participants to view the tool without accessing cellular devices and potentially spreading germs between patients and personal devices. The benefit of laminating the document would allow for facility approved wipes to be used to sterilize the tool between patients.

Future implementation of this QI project would also benefit from extending the implementation period. Lengthening the implementation period to a minimum of 6 months would allow participants to become more familiar with the reference tool and provide results that more accurately represent participant's perceptions regarding the efficacy of the reference tool.

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Walter, M. (2023). Cardiologist ordered to pay $2.6M after foreign material left in patient's femoral artery. *Cardiovascular Business.* https://cardiovascularbusiness.com/topics/healthcare-management/healthcare-economics/cardiologist-ordered-pay-26m-medical-malpractice

Appendix A

Literature Concepts Table

	Concept 1: ECG Lead	Concept 2: Accuracy/Medical Error	Concept 3: Education
Keywords (these are the “normal” words you would use anywhere)	ECG lead or electrode	Inaccurate or error or medical error	Education
PubMed MeSH (subject heading specific to PubMed)	("electrocardiography"[MeSH Terms]	("medical errors"[MeSH Terms] "artifacts"[MeSH Terms]	"education"[MeSH Terms] "teaching"[MeSH Terms]
CINAHL Subject Terms (Subject headings specific to CINAHL)	((MH "Electrocardiography") OR (MH "Electrodes"))	((MH "Health Care Errors") OR (MH "Treatment Errors") OR (MH "Diagnostic Errors") OR (MH "Measurement Error"))	(MH “Education”)
Google Scholar	(ECG Lead)	(Medical Error)	(Education)

Appendix B

Literature Search Log

Search date	Database or search engine	Search strategy	Limits applied	Number of citations found/kept	Rationale for inclusion/exclusion of items
09/18/22	PubMed	(EKG OR ecg OR electrocardiogram) AND (inaccurate OR medical error OR artifact) AND (education) ((("electrocardiography"[MeSH Terms] OR "electrocardiography"[All Fields] OR "ekg"[All Fields] OR ("electrocardiography"[MeSH Terms] OR "electrocardiography"[All Fields] OR "ecg"[All Fields]) OR ("electrocardiogram s"[All Fields] OR "electrocardiography"[MeSH Terms] OR "electrocardiography"[All Fields] OR "electrocardiogram"[All Fields] OR "electrocardiograms"[All Fields])) AND ("inaccurate"[All Fields] OR "inaccurately"[All Fields] OR ("medical errors"[MeSH Terms] OR ("medical"[All Fields] AND "errors"[All Fields]) OR "medical errors"[All Fields] OR ("medical"[All Fields] AND "error"[All Fields]) OR "medical error"[All Fields]) OR ("artifacted"[All Fields] OR "artifacts"[MeSH Terms] OR "artifacts"[All Fields] OR "artifact"[All Fields])) AND ("educability"[All Fields] OR "educable"[All Fields] OR	2017-2023 English	88 Found/ 5 Kept	Included articles pertaining to EKG lead placement and excluded articles only pertaining to EKG interpretation. Limited to within the last five years. Included articles about EKG lead education or learning and excluded articles only about education about interpretation or other irrelevant medical education. English language only selected.

		"educates"[All Fields] OR "education"[MeSH Subheading] OR "education"[All Fields] OR "educational status"[MeSH Terms] OR ("educational"[All Fields] AND "status"[All Fields]) OR "educational status"[All Fields] OR "education"[MeSH Terms] OR "education s"[All Fields] OR "educational"[All Fields] OR "educative"[All Fields] OR "educator"[All Fields] OR "educator s"[All Fields] OR "educators"[All Fields] OR "teaching"[MeSH Terms] OR "teaching"[All Fields] OR "educate"[All Fields] OR "educated"[All Fields] OR "educating"[All Fields] OR "educations"[All Fields])) AND (2017:2022[pdat])			
09/18/22	CINAHL	((MH "Electrocardiography") OR (MH "Electrodes")) AND ((MH "Health Care Errors") OR (MH "Treatment Errors") OR (MH "Diagnostic Errors") OR (MH "Measurement Error"))	2017-2023 English	466 Found/ 6 Kept	Included articles pertaining to EKG lead placement and excluded articles only pertaining to EKG interpretation. Limited to within the last five years. Included articles about EKG lead education or learning and excluded articles only about education about interpretation or other irrelevant medical education. English language only selected.
09/18/22	Google Scholar	(ECG lead) AND (medical error) and (education)	2017-2023 English	17,800 found (Reviewed 12 pages)/ 7 kept	Included articles pertaining to EKG lead placement and excluded articles only pertaining to EKG

					interpretation. Limited to within the last five years. Included articles about EKG lead education or learning and excluded articles only about education about interpretation or other irrelevant medical education. English language only selected.

Appendix C

Literature Matrix

Authors	Purpose and take home message	Design/ Analysis/ Level of Evidence	IV DV or Themes concepts and categories	Instr. Used	Sample Size/ Location	Sample method	Subject Characteristics	Comments/ critique of the article/ methods GAPS
Rajaganeshan, R., Ludlam, C. L., Francis, D. P., Parasramka, S. V., & Sutton, R. (2008). Accuracy in ECG lead placement among technicians, nurses, general physicians and cardiologists. *International Journal of Clinical Practice, 62(1), 65–70*. https://doi.org/10.1111/j.1742-1241.2007.01390..x	This study noted the variability of lead placement accuracy among different educational levels. According to the study, cardiac technicians were the most accurate followed by nurses, physicians, and cardiologists.	Level VI: Questionnaire testing correct lead placement against national standard	IV: Accuracy of ECG lead placement, DV: Education level	Questionnaire	119, Six Hospitals among Greater London	Provided question-naire to particip-ants and instructed to place ECG leads in correct location	Cardiac technician: 10, Nurse: 37, Non-cardiologist physician (NCF): 52, House Officer of NCF: 15, Senior house officer of NCF:15, Registrar of NCF: 19, Consultant of NCF: 3, Cardiologist (C): 20, Senior house officer of C: 5, Registrar of C: 12, Consultant of C: 3	Limitations: None Usefulness: Notes variability and inaccuracy of ECG lead placement Synthesis: Cardiac technicians are among the most accurate lead placers when compared to nurses, physicians, and cardiologist. High variability and inaccuracy was noted among all educational levels.

Kania, M., Rix, H., Fereniec, M. Zavala-Fernandez, H., Janusek, D., Mroczka, T., Stix, G., Maniewski, R. (2014). The effect of precordial lead displacement on ECG morphology. *Medical & Biological Engineering & Computing 52, 109–119.* https://doi.org/10.1007/s11517-013-1115-9	There is increased morphology with inaccurate placement of precordial leads which can lead to an incorrect diagnosis.	Quantitative comparison of frequency and amplitude of ECG waves, Level II	IV: ECG accuracy, DV: Precordial lead placement	Cross correl-ation method used with frequenc y and amplitud e of ECG leads on patient compare d to alternati ve lead placeme nt	60, General Hospital of Medical University of Vienna (Austria)	Perform-ed ECG on 60 men and noted changes in waves after lead alteration	Men 38-83 years of age with diagnosed cardiac pathology	Comments: Placement of precordial leads is a significant determinant of ECG accuracy Limitations: Only men were used in the study. It was noted that women often experience inaccurate placement due to breast tissue.

Medani, S., Hensey, M., Caples, N., Owens, P. (2017). Accuracy in precordial ECG lead placement: Improving performance through a peer led educational intervention. *Journal of Electrocardiology. (51). Pp 50-54*	Incorrect ECG lead placement is common among healthcare professionals. Annual training and competency checks must be incorporated for continuous quality improvement	Pre and post assessment of lead placement accuracy after education; Level IV	IV: Accuracy of ECG lead placement, DV: Educational interventi-on	Placing ECG leads on manikin and charting position with radar plot.	100, Hospital in the UK (not named)	Assessed ECG placemen-t accuracy before and after educationa-l interventi-on	Doctors (34), nurses (56), and cardiac technicians (10)	Limitations: None Usefulness: Well documented improvement strategies for inaccurate ECG lead placement Synthesis: The use of radar plot well documents inaccuracy or ECG lead placement. Also shows improvement after education
Gregory, P., Paget, S., & Kilner, T. (2019). 01 Accuracy of ECG chest lead placements by paramedics. *Emergency Medicine Journal 36*(10)	High level of variability among paramedics placing ECG leads with only 5.8% placing correctly	Quantitative experiment of lead placement on manikin; Level VI	None	Placement of ECG leads on manikin with 19mm tolerance for correctness	52, Emergency services show in Birmingha-m, UK	Random Participa-nts at Emergen-cy Services Show volunteer-ed to place leads on manikin	Registered Paramedics	Limitations: sample size of 52 leaves room for sample size improvement Usefulness: Notes inaccuracy of ECG lead placement Synthesis: Paramedics in the study displayed high variability and inaccuracy of ECG lead placement

doi:https://doi.org/10.1136/emermed-2019999abs.1								
Giannetta, N., Campagna, G., Di Muzio, F., Di Simone, E., Dionisi, S., & Di Muzio, M. (2020). Accuracy and knowledge in 12-lead ECG placement among nursing students and nurses: a web based Italian study. *Acta Bio-medica, 91(12-S).* e2020004. https://doi.org/10.23750/abm.v91i12-S.10349	There is limited education provided to nurses and nursing students about ECG lead placement and significance. After education in the study, participants showed improvement in ECG lead placement, knowledge, and significance.	Quantitative pilot study with questionnaire, Level VI	IV: Accuracy and knowledge of ECG lead placement , DV: Educational intervent-on	Web based question-aire	484, Italian Nursing School	Provided web based question-aire to nurses and nursing students	Nurses (387), Nursing students (97)	Limitations: Data collection done on web based survey may lend itself to being completed on a voluntary basis by those who are interested and motivated in research Usefulness: Shows the link to education and accuracy of lead placement and theoretical knowledge. Synthesis: Nurses and nursing students lack skills in ECG lead placement as well as the concept behind the clinical intervention

Rjoob, K., Bond R.,Finlay, D., McGilligan, V.,Leslie, S.J.,Rababah, A., Guldenring, D., Iftikhar, A., Knoery, C., McShane, A., Peace, A. (2020). Machine learning techniques for detecting electrode misplacement and interchanges when recording {ECGs}: A systematic review and meta-analysis. *Journal of Electrocardiology. (62) pp. 116123*	ECG lead placement can lead to misdiagnosis and have effects on clinical decision making. As providers it is essential to learn the specific ECG machine in order to detect possible inaccuracies with lead placement.	Systematic review, qualitative analysis, and metanalysis, Level VI evidence	None	A search of three online database s including- g IEEE, PubMed and Science Direct identified 228 articles, while 3 articles were included from additional sources from coauthors. According to the eligibility criteria, 14 articles were selected.	14, Study conducted in UK using multiple databases	3 Online database	1) original studies in ECG lead misplacement recognition that are written in English, 2) clearly defined ECG dataset, features, method for misplacement detection, 3) type of electrode misplacement (vertical chest electrode misplacement, chest electrode switching or limb leads reversal/inter change). Studies were excluded if they did not use machine learning to detect misplacement or if the study did not clarify	Limitations: None Usefulness: Metanalysis of numerous articles on ECG lead inaccuracy and clinical implications Synthesis: Highly documented variability and inaccuracy of ECG lead placement can lead to misdiagnosis and potential harm. This metanalysis is beneficial because it compares several articles already chosen for this matrix.

							the ECG dataset or	

							patient diagnosis. Two reviewers applied screening to avoid bias in the inclusion or exclusion process.	

American Society of Anesthesiol-ogists. (2020). Standards for basic anesthetic monitoring. Retrieved September 23, 2022, from https://www.asahq.org/standards-andguidelines/standards-forbasicanesthe ticmonitoring	Established guidelines for ECG monitoring during anesthetic procedures	None	None	None	None, United States	None	None	This document provided by the American Society of Anesthesiologists provides a basis for standards of care and precisely defines the need and importance for accurate ECG monitoring during anesthetic procedures.

Rehman, M., & Rehman, N. U. (2020). *Precordial ECG lead mispositioning : Its incidence and estimated cost to healthcare.* 12(7). https://doi.org/ 10.7759/cureus .9040	Incorrect ECG lead placement has the potential to cause significant financial implications for the health care system	Qualitative study, Level III evidence	Concept: Incorrect ECG lead placement	GE Marquett e™ Muse system's criteria for first line autoanalysis, Young's criteria of RV3 ≤2 mm was employe d for secondar y manual analysis	1,018 subjects, 534 were female (52.5%) and 494 were male (48.5%)./ Guthrie Clinic in Pennsyl-vania	Retrieved using GE Muse™ 8.0.1 Cardio-logy Inform System	All consecutive ECG done in Guthrie Clinic during 2018	While the size of this study is limited to only the Guthrie Clinic, the results of the study are applicable nationwide. Incorrect ECG lead placement has severe financial implications that have the potential to cost the health care system billions of dollars annually.

Note: Key to Levels of Evidence: I: Systematic review/meta-analysis of randomized controlled trials (RCTs); II: RCTs; III: Nonrandomized controlled trials; IV: Controlled cohort studies; V: Uncontrolled cohort studies; VI: Descriptive or qualitative study, case studies, EBP implementation and QI; VII: Expert opinion from individuals or groups. Adapted from *Evidence-based practice in nursing and healthcare: A guide to best practice* (4th ed.), by B. M. Melnyk and E. Fineout-Overholt, 2019, p. 131. Copyright 2019 by Wolters Kluwer.

Appendix D

Project Approvals

Center for Research and Grants [redacted]

Quality Improvement Project vs. Human Research Study Determination Form

This worksheet is a guide to help the submitter to determine if a project or study is a quality improvement (QI) project or research study, is involving human subjects or their individually identifiable information, and if IRB approval as defined by the Health and Human Services (HHS) or Food and Drug Administration (FDA) is required. (For more guidance about whether the activity meets the definition of Human Subjects Research see the IRB FAQs or the Human Subject Research Decision Chart)

Please use Microsoft Word to complete this form providing answers below. For signatures, please hand sign or convert into a PDF file and electronically sign. Once completed and signed please email the form to the [redacted] for Research and Grants [redacted] at CRG.Quality@[redacted].com. A CRG team member will contact you with the results of their review and may request additional information to assist with their determination. The determination will be made in conjunction with the UMCIRB office.

Project Title: Quality Improvement DNP Project: Perioperative ECG Lead Placement		
Funding Source: None		
Project Leader Name: Stephen Whedbee, BSN, SRNA /Travis Chabo, PhD, CRNA ☐ **Ed.D.** ☐ **J.D.** ☐ **M.D.** ☐ **Ph.D.** ☐ **Pharm.D.** ☐ **R.N.** ☐ **Other(specify):**		
Job Title: ECU SRNA/ECU CRNA Faculty	**Phone:** [redacted]	**Email:** chaboT14@ecu.edu
	Primary Contact/ Project Leader: Stephen Whedbee, BSN, SRNA	
	Phone: [redacted]	**Email:** whedbees11@students.ecu.edu

Key Personnel/ Project Team members:

Name and Degree:	**Department:** (Affiliation if other than ECU Health)	**Email:**
Stephen Whedbee, BSN, SRNA	ECU Nurse Anesthesia Program	whedbees11@students.ecu.edu
Travis Chabo, PhD, CRNA	ECU Nurse Anesthesia Program	chaboT14@ecu.edu

QI/QA Assessment Checklist:

Consideration	Question	Yes	No
PURPOSE	Is the PRIMARY purpose of the project/study to: • IMPROVE care right now for the next patient? OR • IMPROVE operations outcomes, efficiency, cost, patient/staff satisfaction, etc.?	☒	☐
RATIONALE 1	The project/study falls under well-accepted care practices/guidelines or is there sufficient evidence for this mode or approach to support implementing this activity or to create practice change, based on: • literature • consensus statements, or consensus among clinician team	☒	☐
RATIONALE 2	The project/study would be carried out even if there was no possibility of publication in a journal or presentation at an academic meeting. (**Please note that answering "Yes" to this statement does not preclude publication of a quality activity.)	☒	☐
METHODS 1	Are the proposed methods flexible and customizable, and do they incorporate rapid evaluation, feedback and incremental changes?	☒	☐
METHODS 2	Are patients/subjects randomized into different intervention groups in order to enhance confidence in differences that might be obscured by nonrandom selection? (Control group, Randomization, Fixed protocol Methods)	☐	☒
METHODS 3	Will there be delayed or ineffective feedback of data from monitoring the implementation of changes? (For example to avoid biasing the interpretation of data)	☐	☒
METHODS 4	Is the Protocol fixed with fixed goal, methodology, population, and time period?	☐	☒
RISK	The project/study involves no more than minimal risk procedures meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.	☒	☐
PARTICIPANTS	Will the project/study only involve patients/subjects who are ordinarily seen, cared for, or work in the setting where the activity will take place?	☒	☐
FUNDING	Is the project/study funded by any of the following? • An outside organization with an interest in the results • A manufacturer with an interest in the outcome of the project relevant to its products • A non-profit foundation that typically funds research, or by internal research accounts	☐	☒

If all of the check marks are inside the shaded gray boxes, then the project/study is very likely QI and not

human subject research. Projects that are not human subject research do not need review by the IRB.

In order to assess whether your project meets the definition of human subject research requiring IRB review or may qualify as a quality improvement/assurance activity, please provide the following information: 1. Project or Study Summary:

Please provide a **summary of the purpose and procedures** as well address all of the following:

The purpose of this quality improvement project is to assess CICU nurses' perceptions of adequacy of a newly developed ECG lead placement guide.

A quick-reference ECG lead placement guide, based upon accepted national guidelines, will be developed. Cardiac Intensive Care Unit (CICU) nurses at [redacted] will be asked several questions (through Qualtrics) about their perceptions of the adequacy of their currently used guidelines and preparedness for ECG lead placement. An educational video about the use of the newly developed ECG lead reference guide will be made available to them, and they will be asked to use the guide for two weeks. Upon completion of the twoweek utilization period, they will be asked to complete a questionnaire about their perceptions of the adequacy of the guide. Qualtrics survey software will be used to gather participant perceptions of their ECG lead placement practices prior to implementation of the intervention and of their perceptions of the acceptability and adequacy of the intervention (educational presentation and guide) post implementation of the intervention. No patient information will be recorded or maintained during this project.

a) The project's primary purpose.
   - This Doctor of Nursing Project will assess the perceived efficacy of a standardized educational aid (a newly developed ECG lead placement guide) designed to streamline ECG lead placement and increase consistency among Cardiac Intensive Care Unit (CICU) nurses. ECG lead placement education will include standard, 6-lead placement and alternative placement required for varying surgical procedures and positioning. b) The project design.
   - The project will consist of a single Plan, Do, Study, Act cycle using a pre- and postintervention survey design.

c) Any interaction or intervention with humans.
   - CICU nurse participants will be contacted via email and asked to complete a pre-survey and then utilize an informational tool (a newly developed ECG lead placement guide) based on current evidence that aligns with practices currently accepted within the facility to support their practice regarding ECG lead placement. After two weeks they will then be asked to complete a post-survey addressing their perceptions of the informational guide intervention and their own practice. The primary researcher will be available electronically, by phone, or in person to consult with participants as needed.

d) A description of the methods that will be used and if they are standard or untested.

- The intervention for this project will be a newly created informational tool newly developed (ECG lead placement guide) focused on ECG lead placement which is based on current evidence and falls within current accepted practice standards within the facility.

e) Specify where the data will come from and your methods for obtaining this data -please specify who/where (i.e., CRG will provide you with the data, or someone from a specific department will provide you with the data, or you will pull it yourself).
   - Data will be gathered directly from participants through completion of Qualtrics pre- and post-surveys delivered and completed electronically.

f) Specify what data will be used and any dates associated with when that data was originally collected (i.e Patient Name, Diagnosis, Age, Sex), *If applicable, please attach your data collection sheet.*
Aside from participant email and IP addresses, no identifiable data will be gathered. Data of interest is participant opinions and perceptions of practice and the newly developed informational tool (ECG lead placement guide).

g) Where will the data (paper and electronic) for your project be stored? Please specify how it will be secured to protect privacy and maintain confidentiality. For paper data, please provide physical location such as building name and room number and that it will be kept behind double lock and key. For electronic data, please provide the file path and folder name network drive where data will be stored and specify that it is secure/encrypted/password protected. If using other storage location, please provide specific details.
   - All data will be gathered using Qualtrics survey software then transferred to Excel for analysis. The only identifying information will be email and IP addresses. Qualtrics survey software is accessed through ECU and involves multifactorial password protection. Data in Excel will be on a password protected personal laptop. Email and IP addresses will be deleted from Excel files after both surveys have been completed and analysis of results begins.

h) Please specify how long data will be stored after the study is complete? (Keep in mind that data collected/ generated during the course of the project that includes protected health information (PHI) should have identifiers removed at the earliest opportunity.)
   - No PHI will be collected for this project. Data will be stored in Qualtrics and in Excel files (de-identified) until student graduation, anticipated to be spring of 2024.

i) Please specify how the collected data will be used (internal/external reports, publishing, posters, etc.) and list name(s) of person responsible for de-identification of data before dissemination.
   - The de-identified data will be analyzed with results shared via a poster presentation to the ECU Nurse Anesthesia Program students and faculty, with participants invited to view the presentation remotely. If requested, a presentation of results to the participating department will be provided. Additionally, analysis of results will be addressed in a DNP Project Paper, completion of which is required for program graduation. This paper will be posted in the ECU digital repository, The Scholarship. Stephen Whedbee will be responsible for de-identification of all data prior to dissemination.
   -

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2. If the Primary purpose of your project is for QI, have you obtained approval from the [redacted] operational leader within your department or health system:

☐ **No [STOP. Please contact the appropriate operational leader for approval before proceeding.]**

☒ **Yes** [Please specify here whom and obtain their signature in the signature section below]

[redacted] Operational Mgr/Leader Name: [redacted], RN, MSN

DocuSigned by:
[redacted]
BA4CD9E7FB8B40E...

3/1/2023 | 7:29 PM EST

[redacted] Operational Mgr/Leader Signature **Date**

Please note:

- By submitting your proposed project/study for QI determination you are certifying that if the project/study is established to qualify as QI project, you and your Department would be comfortable with the following statement in any publications regarding this project: "This project was reviewed and determined to qualify as quality improvement by the [redacted] Center for Research and Grants."
- If you are submitting a Poster to Media Services, you will also need to submit this Quality Determination Form or IRB Approval to Media Services for printing.
- If the [redacted] CRG determines the activity is not human subject research, then any presentation, publication, etc. should not refer to the activity as "human subject research," "exempt research," or "expedited research."

Attestation of Understanding

My signature below indicates that I fully understand that HIPAA Privacy standards as they apply to Quality Projects involving Protected Health Information and patient medical records as outlined below.

Under HIPAA's minimum necessary provisions, [redacted] must make reasonable efforts to limit PHI to the minimum necessary to accomplish the purpose of the use, disclosure or request.

Under HIPAA, a Covered Entity ([redacted]) can disclose PHI to another CE ([redacted]) for the following subset of health care operations activities of the recipient CE without needing patient consent:

- Conducting quality assessment and improvement activities
- Developing clinical guidelines
- Conducting patient safety activities as defined in applicable regulations
- Conducting population-based activities relating to improving health or reducing health care cost

Identified [redacted] healthcare data utilized in this project should not be shared outside of the CE without a fully executed data use/sharing agreement. [redacted] leadership reserves the opportunity to review all articles for dissemination/ publication for which [redacted] healthcare data has been utilized.

Stephen C Wheelus

Project Leader Signature

2/12/23

Date

----------for [redacted] CRG Use Only----------

NHSR vs. HSR Determination:

☑ **Not Human Subject Research:** The [redacted] CRG has determined that based on the description of the project/study, approval by the IRB is not necessary. Any changes or modifications to this project may be discussed with the [redacted] CRG at that time to ensure those changes do not elevate the project to human research that would need IRB approval.

☐ **Human Subject Research:** This project/study requires review by the IRB prior to initiation. An application in the electronic IRB submission system should be submitted.

Approval Signatures:

[redacted] **CRG Reviewer:** [redacted] **Date:** 3/6/2023

[redacted] **Office Staff Reviewer:** [redacted] **Date:** 3/8/23

[redacted]

Click "download PDF" to save a copy of this page for your records.
Note: The IRB Office does not maintain copies of your responses.

Below is a summary of your responses

Download PDF

Quality Improvement/Program Evaluation Self-Certification Tool

Purpose:
Projects that do not meet the federal definition of human research pursuant to 45 CFR 46 do not require IRB review. This tool was developed to assist in the determination of when a project falls outside of the IRB's purview.

Instructions:
Please complete the requested project information, as this document may be used for documentation that IRB review is not required. Select the appropriate answers to each question in the order they appear below. Additional questions may appear based on your answers. If you do not receive a STOP HERE message, the form may be printed as certification that the project is "not research", and does not require IRB review. The IRB will not review your responses as part of the self-certification process. For projects being done at [redacted] site support will be required. Please email crg.quality@[redacted] to obtain site support from [redacted].

Name of Project Leader:

Travis Chabo

Project Title:

Quality Improvement DNP Project: Perioperative ECG Lead Placement

Brief description of Project/Goals:

The purpose of this quality improvement project is to assess anesthesia providers' perceptions of adequacy of newly developed reference resource for proper EKG lead placement. Process: A quick-reference perioperative guide to proper EKG lead placement, based upon accepted national guidelines, will be developed. Cardiac Intensive Care Unit care nurses at [redacted] will be asked several questions (through Qualtrics) about their perceptions of the adequacy of their current EKG lead placement and their current practice. An educational video about the use of a newly developed reference tool for proper EKG lead placement will be made available to them, and they will be asked to use the reference tool for two weeks. Upon completion of the two-week utilization period, they will be asked to complete a questionnaire about their perceptions of the adequacy of the proper lead placement reference and their current practice. Qualtrics survey software will be used to deliver the intervention link and gather participant perceptions prior to and post implementation of the project. No patient information will be recorded or maintained during this project.

Will the project involve testing an experimental drug, device (including medical software or assays), or biologic?

- ○ Yes
- ● No

Has the project received funding (e.g. federal, industry) to be conducted as a human subject research study?

- ○ Yes
- ● No

Is this a multi-site project (e.g. there is a coordinating or lead center, more than one site participating, and/or a study-wide protocol)?

- ○ Yes
- ● No

Is this a systematic investigation designed with the intent to contribute to generalizable knowledge (e.g. testing a hypothesis; randomization of subjects; comparison of case vs. control; observational research; comparative effectiveness research; or comparable criteria in alternative research paradigms)?

- ○ Yes
- ● No

Will the results of the project be published, presented or disseminated outside of the institution or program conducting it?

- ● Yes
- ○ No

Would the project occur regardless of whether individuals conducting it may benefit professionally from it?

- [x] Yes
- [ ] No

Does the project involve "no more than minimal risk" procedures (meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests)?

- [x] Yes
- [ ] No

Is the project intended to improve or evaluate the practice or process within a particular institution or a specific program, and falls under well-accepted care practices/guidelines?

- [x] Yes
- [ ] No

Based on your responses, the project appears to constitute QI and/or Program Evaluation and IRB review is not required because, in accordance with federal regulations, your project does not constitute research as defined under 45 CFR 46.102(d). If the project results are disseminated, they should be characterized as QI and/or Program Evaluation findings. Finally, if the project changes in any way that might affect the intent or design, please complete this self-certification again to ensure that IRB review is still not required. Click the button below to view a printable version of this form to save with your files, as it serves as documentation that IRB review is not required for this project. 11/25/2022

Appendix E

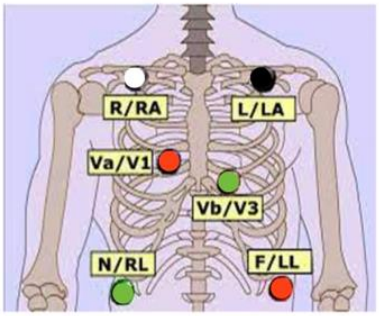
Reference Tool and Video Script

ECU

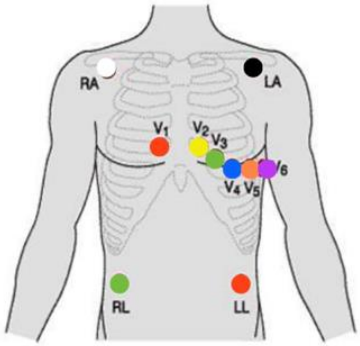
ECG Lead Placement

Haley Cutler, BSN , SRNA
Chad Greene, BSN, SRNA
Stephen Whedbee, BSN, SRNA
Lindsay Wright, BSN, SRNA
College of Nursing,
East Carolina University

Electrode	Color	Position
RA	White	Right Arm
LA	Black	Left Arm
RL	Green	Right Leg
LL	Red	Left Leg
Va/V1	Red	Sternal Edge Right 4th ICS
Vb/V3	Green	Midway between sternal edge Left 4th ICS and MCL Left 5th ICS



Electrode	Color	Position
RA	White	Right Arm
LA	Black	Left Arm
RL	Green	Right Leg
LL	Red	Left Leg
V1	Red	Sternal Edge Right 4th ICS
V2	Yellow	Sternal Edge Left 4th ICS
V3	Green	Midway between V2 and V4
V4	Blue	Mid-Clavicular Line Left 5th ICS
V5	Orange	Between V4 and V6 Left 5th ICS
V6	Purple	Mid-Axillary Line Left 5th ICS



Right-Sided Electrode Placement

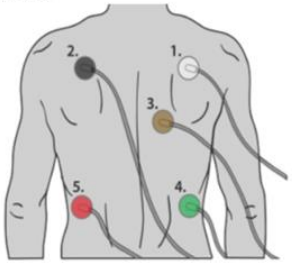
- When right sided ischemia is suspected a right sided ECG can be performed for further diagnosis
- A complete set of right sided leads is obtained by placing leads V1-6 in a mirror image position on the right side of the chest
- It can be simpler to leave V1 and V2 in their usual positions and just transfer leads V3-6 to the right side of the chest (i.e. V3R to V6R

Right sided 12 lead ECG lead placement

Prone ECG Lead Placement

- A prone ECG lead waveform is obtained by placing leads in a mirror image position on the back
- While this is a five-lead tracing, the additional V3 lead may also be utilized in the mirror image position for a 6-lead tracing

1. RA
2. LA
3. V
4. RL
5. LL



"Hello, our names our Haley Cutler, Chad Greene, Stephen Whedbee and Lindsay Wright. As part of our DNP project in ECU's CRNA program, we have developed the following ECG lead placement quality improvement project. Thank you in advance for your time.

The purpose of our project is to assess various healthcare providers' perceived impact of a newly developed reference tool for proper ECG lead placement. This presentation accompanies the PDF reference tool included in the email you received.

We will start with the basics of electrophysiology. The leads are arranged so that the wave of depolarization traveling toward a positive recording electrode displays a positive voltage on the ECG tracing. A wave of repolarization moving away from a positive recording electrode displays a positive ECG voltage. The voltage is negative if the depolarization wave is moving away from the positive recording electrodes or a repolarization wave is moving toward the electrode. Depolarization or repolarization waves traveling perpendicular to the lead axis of a positive recording electrode display no net voltage. Lastly, magnitude of the recorded voltage is related to the mass of the muscle undergoing depolarization or repolarization.

What drives the depolarization are action potentials generated by changes in ion conductance via opening and closing of ion channels. The inward movement of Na+ is responsible for the initial depolarization, followed by the delayed inward movement of Ca2+ into the cell which prolongs the depolarization phase, and finally the outward movement of K+ repolarizes the membrane and brings it back to its resting potential. Remember, the ECG is only monitoring electrical activity, not muscle activity. We place the ECG leads to obtain a tracing that looks like the picture in the bottom left: clear p waves, QRS complexes, and T waves with as little artifact as possible.

There are 3 types of leads in the typical ECG waveforms. These are the unipolar or augmented leads (AVR, AVL, aVF), the bipolar leads (I, II, and III), and the precordial or chest leads, (V1-V6). As you can see, the three limb electrodes I, II and III form a triangle at the right arm, left arm, and left leg. This is known as Einthoven's triangle. The right leg electrode (the ground lead) removes artifact from the ECG and does not directly participate in the ECG tracing. The three augmented leads give additional views by reading potential differences across the heart in three more directions on the frontal plane. The precordial leads are placed on the sternum traveling in a posterior direction, creating a transverse plane with which to view the heart's electrical signal in addition to the frontal plane given by the limb leads.

Lead groupings are categories of leads based on the area of the heart they examine. Inferior leads look down towards the feet and are leads II, III, and aVF. Antero-septal leads overview the ventricular septum and anterior wall and are leads V1 and V2. Anterior leads are mainly over the anterior wall and are leads V3 and V4. Lateral leads examine the lateral wall and area leads I, aVL, V5, and V6.

Now onto the standard 6-lead ECG placement. We have the corresponding leads on the right arm, left arm, right leg, and left leg. The Va or V1 lead is at the right sternal edge in the 4th intercostal space. The Vb or V3 lead is midway between the sternal edge at the left 4th intercostal space and mid-clavicular line 5th intercostal space.

12-lead ECG placement includes the six leads from the previous slide plus V2, which is at the left sternal edge of the 4th intercostal space; V4, which is at the left mid-clavicular line at the 5th intercostal space; V5 which is between V4 and V6; and V6, which is at the left mid axillary line at the 5th intercostal space.

For a right sided ECG, a complete set of right sided leads may be obtained by keeping the limb leads in their same positions and changing the V1-V6 leads to be a right sided mirror image of the left side of chest. It may be simpler to leave V1 and V2 in their usual positions and just transfer V3-V6 to the right side of the chest. Remember, the position of the lead is what determines your waveform, not the lead itself.

A prone ECG lead waveform is obtained by placing leads in a mirror image position on the back. This picture does not include the V3 lead but it would be added in its mirror image position for the complete 6-lead tracing.

We appreciate your time in viewing this presentation as well as your participation in this project. We look forward to hearing about your usage of the PDF reference tool in the post-intervention survey."

Appendix F

Communication with Participants

Initial Pre-Survey and Video Email to Participants

Dear CICU Nurses,

Thank you for considering participating in a quality improvement project titled "ECG Lead Placement." The purpose of this project is to assess the perceived efficacy of an ECG lead reference tool at [redacted].

Participation is voluntary and will involve completing a short pre-intervention survey, viewing a brief video, utilizing an ECG lead reference tool in your nursing practice for two weeks (at your discretion), and completing a short post-intervention survey when the two-week implementation period is over.

Each survey and the video should take less than 2-4 minutes to complete. The surveys were created and are completed using Qualtrics® survey software. The use of this ECG lead reference tool falls within currently accepted practice in your work area. Your participation is voluntary and confidential. We will share the results of this QI study with you upon completion. First, complete the pre-intervention survey link here.

Following completion of the survey, view the project overview presentation video and reference tool. Feel free to download the reference tool as a PDF for quick reference or grab a paper copy provided in the break room.

Again, thank you for your participation in our quality improvement project. If you have any questions, you may also reach out to me or the project chair, Travis Chabo, by email at any time.

Sincerely,

Stephen Whedbee, SRNA

Whedbees11@students.ecu.edu

Project Chair

Travis Chabo, PhD, CRNA

Chabot14@ecu.edu

Pre-Survey and Video Reminder Email to Participants

Hello CICU Nurses,

I just wanted to send a quick reminder about the ongoing DNP Project on ECG lead placement (original email below). If you've already filled out the pre-survey and viewed the video, thank you. If you haven't had a chance to do so yet, it's not too late and would be very helpful and much appreciated. There are still printed reference tools in the break room if you haven't already received one. You may use these at your discretion. After the end of next week, I will begin sending out the post-surveys.

Links:

Pre-Survey

Video:

Please let me know if you have any questions and thank you again for your participation.

Sincerely,

Stephen Whedbee, SRNA

ECU Nurse Anesthesia Program

Class of 2024

Post-Survey Email to Participants

Dear CICU Nurses,

Thank you to everyone who has already completed my pre-survey and viewed the video. It's now time to complete the brief post-survey.

If you have not filled out a pre-survey, I would really and truly appreciate your participation (it's just surveys and a video!). The link to the pre-survey is Here, and you can follow it up by watching the introductory PPT/video here. Physical copies of the reference tool are available for your use if you would like them, but their use is not mandatory for participation in this project.

If you've already completed the first survey, please complete the Post-Survey. It should take less than 2 minutes.

If anyone has questions or issues with any of these links please let me know. Again, thank you to everyone for your help. I look forward to coming back to [redacted] soon.

Sincerely,

Stephen Whedbee, SRNA

ECU Nurse Anesthesia Program

Class of 2024

Final Thank You Email to Participants

Dear CICU Nurses,

I just wanted to say thank you so much to everyone for helping me out with my DNP Project! I have collected all of the data I need to proceed with data analysis and will then be finishing my paper. Once it's complete you all will be able to read it if you'd like. And if you liked the ECG lead reference tool and found it useful, you can continue to implement this into your daily practice.

Thank you again! I hope to work with you more in the future.

Take care,

Stephen Whedbee, SRNA

ECU Nurse Anesthesia Program

Class of 2024

Links:

Pre-Intervention:

https://ecu.az1.qualtrics.com/survey-builder/SV_9KN1nMAE6bCBB5k/edit

Post-Intervention:

https://ecu.az1.qualtrics.com/survey-builder/SV_1FVIzrfTic2mWyy/edit

Appendix G

Survey Questions

Pre-Intervention questions

1. Did you receive formal training on ECG lead placement as part of the onboarding process for your discipline? (For ICU nurses only)

   Yes/No/I don't know

2. How confident do you feel placing ECG leads accurately in standard and alternative positions? (Chart)

   a. Supine: Not able to place, not confident, neutral, somewhat confident, confident

   b. Prone: Not able to place, not confident, neutral, somewhat confident, confident

   c. CV surgery: Not able to place, not confident, neutral, somewhat confident, confident

   d. Abdominal/laparoscopic surgery: Not able to place, not confident, neutral, somewhat confident, confident

3. How often do you experience artifact/incorrect morphology with your current ECG lead placement practice? Never, not often, sometimes/neutral, somewhat often, very often

4. How often do you adjust ECG lead placement for body habitus, position, dressings, etc to achieve an acceptable ECG tracing? Never, not often, neutral, somewhat often, very often

6. How often do you receive patients with inaccurate ECG lead placement? Never, not often, sometimes/neutral, somewhat often, very often

7. Do you currently use standardized methods for ECG lead placement? Never,

not often, sometimes, somewhat often,

very often

8. Do you believe the quality of patient care

could be improved with more accurate

ECG lead placement?

Strongly disagree, disagree, neutral, agree, strongly agree

Post intervention questions:

1. How confident do you now feel placing ECG leads accurately in standard

and alternative positions? Chart

a. Supine: Not able to place, not confident, neutral, somewhat confident, confident

b. Prone: Not able to place, not confident, neutral, somewhat confident, confident

c. CV/Thoracic surgery: Not able to place, not confident, neutral, somewhat confident, confident

d. Abdominal/laparoscopic: Not able to place, not confident, neutral, somewhat confident, confident

2. How often did you adjust placement for body habitus, position, dressings,

poor ECG waveform etc. since receiving tool? Never, not often, neutral/did

not use tool, somewhat often, very often

3. How often have you experienced artifact/incorrect morphology with ECG

lead placement practice since receiving the tool? Never, not often,

sometimes/neutral, somewhat often, very often

4. How likely are you to continue to use this reference tool in the future when

applying ECG leads? Never, not likely, neutral, somewhat likely, very likely

5. This reference tool is easily accessible.

   Strongly disagree, disagree, neutral, agree, strongly agree

6. How often did you use this reference tool in your practice since receiving it?

   Never, not often, sometimes/neutral, somewhat often, often

7. About how much time did it take to reference this reference tool in your daily practice? Less than 1 minute, 1-2 minutes, 3-5 minutes, greater than 5 minutes

8. This reference tool improved the quality of patient care I delivered. Strongly disagree, disagree, neutral, agree, strongly agree

9. After using the reference tool and participating in this QI project, do you think an annual continuing education module on ECG lead placement would improve patient care? Yes/No/I don't know

10. Do you have feedback or suggestions that haven't been already asked? [free text reply]