Prevention and Treatment of Local Anesthetic Systemic Toxicity: A DNP Project

Mary Elise Pierce, BSN, SRNA

Maura S. McAuliffe, PhD, CRNA, FAAN, Project Chair

Nurse Anesthesia Program

College of Nursing, East Carolina University

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Notes from the Author

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I am dedicating this DNP Project to my sister, Karina. Though she is not here to celebrate this academic milestone, she never let me question if I made her proud. Because of her, I grew a great passion for people and medicine. I will always strive to make her proud.

Abstract

Local anesthetic systemic toxicity (LAST) is an adverse event after the administration of local anesthetics that can lead to seizures, cardiac arrest, and death. While rare, this potentially catastrophic event requires immediate diagnosis and treatment. The purpose of this Doctor of Nursing Practice (DNP) quality improvement project is to assess CRNA perceptions of the adequacy of a LAST Quick Reference Guide designed to assist in identifying high-risk patients to quickly diagnose and appropriately treat LAST should it occur. A presentation and visual aids were given to the participating CRNAs, along with pre- and post-implementation surveys via anonymous Qualtrics links. The survey responses were collected and analyzed, showing mixed results. The results showed a net increase in the CRNA awareness of LAST (n=4). However, the overall confidence in maximum dosages of local anesthetics showed a decrease in confidence in the post-implementation responses. These results could be due to an immense amount of information on the QRG, a discrepancy between previous knowledge and what was learned from the QRG, or the possibility of having different participants in the pre- versus post-implementation surveys. The sample size from this project was small, so it is not possible to generalize the findings and further research is recommended. It is anticipated that knowledge gained from this project can be used in future quality improvement projects aimed at improving this rare but potentially catastrophic perioperative event at this facility.

Keywords: local anesthetics, CRNA, local anesthetic systemic toxicity, LAST

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Section I. Introduction

Background

The use of local anesthetics for anesthesia and postoperative anesthesia has increased in recent years. In many instances, regional anesthesia can be used in place of general anesthesia. In the perioperative setting, the benefits of local anesthetics include decreased use of opioids, improved pain control, decreased occurrences of postoperative nausea and vomiting, and increased patient satisfaction (On'Gele et al., 2022).

Local anesthetics work by reversibly binding to voltage-gated sodium channels, slowing the rate of membrane depolarization, and inhibiting the propagation of action potentials in peripheral nerves (Gitman et al., 2019). Due to this mechanism of action, local anesthetics are used to decrease pain signaling from specific areas of the body. Additionally, local anesthetics are able to act on all nerve types, which can lead to a sensory and motor blockade as seen in spinal administration. Cardiac action potentials are initiated by the influx of sodium through the voltage-gated sodium channels to drive the cellular membrane to its threshold. Local anesthetics directly block these voltage-gated sodium channels and decrease the rate of depolarization, increasing the duration of the action potential. In toxic doses, this causes arrythmias and cardiovascular collapse (Gitman et al., 2019).

While local anesthetics have numerous benefits, rare adverse effects such as local anesthetic systemic toxicity (LAST) can occur and lead to catastrophic outcomes. The best way to treat LAST is to prevent it, but when it occurs despite preventive measures, quick identification and treatment are crucial (Mahajan & Derian, 2022). Initial symptoms include agitation, dizziness, auditory changes, peri-orbital numbness, drowsiness, metallic taste, and dysarthria. Symptoms progressively worsen, leading to seizures, loss of consciousness,

arrhythmias, airway loss, and profound hypotension (On'Gele et al., 2022). Anesthetic medications can prevent the identification of patient-reported mild symptoms. Therefore in sedated or anesthetized patients, the first symptoms of LAST may be life-threatening ones such as seizures, arrhythmias, or profound hypotension. Research has demonstrated that LAST occurs at a rate of 1.8 of every 1,000 peripheral nerve blocks (Macfarlane et al., 2021). Because LAST should be a "never-event," any occurrences indicate a need for quality improvement in the use of local anesthetics and the prevention, diagnosis, and treatment of LAST.

At present, there are no national guidelines addressing the prevention published by professional anesthesia groups. However, the American Society of Regional Anesthesia (ASRA) created a checklist for the treatment of LAST. Creating the checklist aligns with their mission statement "to advance the science and practice of regional anesthesia and pain medicine to improve patient outcomes through research, education, and advocacy" (American Society of Regional Anesthesia and Pain Medicine [ASRA], 2014; Neal et al., 2020). With no published prevention guidelines, there is great potential for further developing educational resources or guidelines for the prevention and treatment of LAST.

Organizational Needs Statement

At the partnering institution, more regional anesthesia techniques are being used today than previously; however, there is no institutional tool providing an overview of the best practices for recognizing and treating LAST (M. McAuliffe, personal communication, September 24, 2024). The partnering institution serves 1.4 million people, spanning over 29 counties, and performs approximately 52,721 surgeries each year ([redacted], 2023). With the vast number of operations performed and the increasing use of local anesthetics, there is a need for a guidance tool detailing best practices for the prevention and treatment of LAST. Quality

improvement in the use of local anesthetics and preventing and treating LAST directly aligns with the American Association of Nurse Anesthesiology's (AANA) Standards for Nurse Anesthesia Practice, specifically Standard 1 and Standard 14. Standard 1 includes respect for the patient's rights, including their right to safety, and Standard 14 demands a collaborative culture of safety in the patient care environment (AANA, 2019).

Problem Statement

Local anesthetic systemic toxicity (LAST) is an adverse event after the administration of local anesthetics that occurs at a rate of 1.8 per 1,000 nerve blocks. LAST can lead to seizures, cardiac arrest, and death (Macfarlane et al., 2021). While rare, this potentially catastrophic event requires immediate diagnosis and treatment. Providing a Quick Reference Guide can ensure the provision of life-saving interventions should this event occur.

Purpose Statement

The purpose of this Doctor of Nursing Practice (DNP) quality improvement project is to assess CRNA perceptions of the adequacy of a LAST Quick Reference Guide designed to assist in identifying high-risk patients to quickly diagnose and appropriately treat LAST should it occur. It is anticipated that knowledge gained from this project can be used in future quality improvement projects aimed at improving this rare but potentially catastrophic perioperative event at this facility.

Section II. Evidence

Description of Search Strategies

The purpose of the literature review was to locate evidence to support this quality improvement initiative addressing the prevention, diagnosis, and treatment of LAST. The PICOTS (problem, intervention, comparison, outcome, time, setting) question that helped guide the search was: Would the use of a quick reference guide for local anesthetic systemic toxicity (LAST) increase the confidence of nurse anesthetists caring for patients requiring the use of local anesthetics? The major concepts identified for the literature search were *perioperative*, *LAST*, *reference tool*, and *CRNA*. See Appendix A for the Literature Concepts Table. The major concepts were searched in the major databases of PubMed and Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the search engine Google Scholar, to identify relevant literature (Appendix B).

In PubMed, the search strategy was (local anesthetic systemic toxicity AND perioperative) which pulled the MeSH terms specific to the database (Appendix B). The MeSH terms were as follows: “Perioperative Period” OR “Perioperative Care” OR “Perioperative Medicine,” and “Anesthetics, Local” OR “Anesthetics, Local/Toxicity.” The limits applied to the search were: published within the last five years, written in the English language, and peer-reviewed. Due to the initial lack of sources populated by the search, the time frame for publishing was increased to within the last 15 years. The search resulted in 46 articles. The first five pages of results were reviewed by titles and abstracts, and four articles were retained for further full-text review. The exclusion criteria used to eliminate articles included non-generalizable case studies and articles that did not focus on LAST. The inclusion criteria for the

articles that were retained included the prevention, treatment, and provider general knowledge of LAST.

In CINAHL, the search strategy was (MH "Drug Toxicity") AND (MH "Anesthetics, Local"), terms that were specific to the CINAHL catalog of searches. The same limits were applied to the search: published within the last five years, written in the English language, and peer-reviewed. Like with PubMed, few articles populated so the publishing time frame was also increased to within the last 15 years. This search resulted in eight articles. From the eight results, the titles and abstracts were read to determine relevancy, and five articles were retained for full-text review. The exclusion criteria included non-generalizable case studies and topics or settings not applicable to the project. The articles retained for full text review included relevant data on the prevention, diagnosis, and treatment of LAST.

In Google Scholar, the search strategy was (local anesthetic systemic toxicity) AND (CRNA) AND (perioperative setting). As with PubMed and CINAHL, the limits applied to the search were: published within the last five years, written in the English language, and peer-reviewed. From the search, 578 articles were produced. The first five pages were reviewed by article title and abstract, and twelve articles were retained for further review. As before, the exclusion criteria included non-generalizable case studies and topics or settings that did not apply to the project aim. Exclusion criteria also included articles that also populated from the previous searches in PubMed and CINAHL.

The reference lists of articles identified as being pertinent to this project were reviewed for additional sources. This resulted in the addition of one article that was mentioned in several current, peer-reviewed articles, but was published in 2012. Although this article was published

outside of the initial parameters, it was deemed relevant to this project as it described a quality improvement project that directly applies to this topic and project tool (Neal et al., 2012).

Seven articles were retained for evidence, as seen in Appendix C: Literature Matrix. The hierarchy of evidence from Melynk and Fineout Overholt (2019) was used to organize the retained articles. Level I is the highest level of evidence, and Level VII is the lowest level of evidence. One randomized control trial (Level II), one quasi-experimental control trial (Level III), one descriptive study (Level VI), and four narrative literature reviews/expert opinions (Level VII) were deemed pertinent to the project and compiled in the literature matrix to describe the findings from each source. Few high level of evidence studies were found that addressed improving the prevention, diagnosis, or treatment of LAST, showing a need for additional research on this topic.

Selected Literature Synthesis

Prevention, Diagnosis, and Treatment of LAST

Four articles were selected as evidence for current perspectives on the prevention, diagnosis, and treatment of LAST. Three of these were narrative literature reviews (Level VII) and one was Expert Opinion (Level VII). All four were published within the last six years. The publications examining prevention, diagnosis, and treatment of LAST were considered relevant to information intended for display on the quick reference guide.

Patient-associated risk factors for LAST include extremes of age and the presence of pre-existing conditions. Infants and the elderly are susceptible to LAST due to low levels of lean muscle mass and weight (Gitman et al., 2019). The elderly are at additional risk because they have decreased perfusion to organs that metabolize local anesthetics, so drugs remain in the plasma for longer periods (El-Boghdadly et al., 2018). Adults with renal or hepatic impairments

have difficulty clearing local anesthetics metabolized by the kidneys or liver. To lower the risk of developing LAST, El-Boghdadly et al. (2018) recommend decreasing dosages for vulnerable patient populations. Using ultrasound guidance while administering local anesthetics for peripheral blocks reduces the risk of LAST by up to 65% (El-Boghdadly et al., 2018; Macfarlane et al., 2021). Administering small doses with frequent aspiration during the procedure helps ensure correct placement. After correct needle placement is confirmed, it is important to use the least amount of the drug required for the block (El-Boghdadly et al., 2018).

The onset of LAST can vary from less than a minute from injection to over an hour (Macfarlane et al., 2021). Milder initial symptoms include agitation, dizziness, auditory changes, peri-orbital numbness, drowsiness, metallic taste, and dysarthria. Symptoms progressively worsen to potential seizures, loss of consciousness, arrhythmias, loss of airway, and profound hypotension (El-Boghdadly et al., 2018; Gitman et al., 2019; Macfarlane et al., 2021). It is important to note that patients on prolonged infusions may have delayed or diminished symptoms (Gitman et al., 2021).

The literature supports prompt symptom identification, followed by discontinuation of local anesthetics, patient stabilization, and emergency management. If suspected, the local anesthetic must be discontinued immediately (El-Boghdadly et al., 2018; Gitman et al., 2019; Macfarlane et al., 2021). Provision oxygen and ventilation are the most important in an emergency. After securing the airway, continuing with other advanced cardiac life-saving (ACLS) interventions is necessary. For almost 15 years, research has demonstrated that lipid emulsion administration has improved patient outcomes (Gitman et al., 2019). The lipid emulsion acts indirectly as a lipid shuttle, binding and redistributing the drug to the liver, where the local anesthetics are metabolized. Additionally, the lipid emulsion improves cardiac function

as a positive inotrope, improving cardiac output (Lee & Sohn, 2023). Current practice guidelines strongly advise avoiding vasopressin, calcium channel blockers, beta-blockers, and administration of any additional local anesthetics in the resuscitation period as they may potentiate the life-threatening symptoms (El-Boghdadly et al., 2018; Gitman et al., 2019; Macfarlane et al., 2021).

Improving the Management of LAST

To develop a quick reference guide for LAST, three articles published within the last 15 years were retained and used. Of these, one was a descriptive study (Level VI), one a randomized control trial (Level II), and one was a quasi-experimental study (Level III). All three articles emphasized the necessity for visual aids or checklists while caring for high acuity, high specificity, and low occurrence cases – such as LAST, which further supports the methods used in this quality improvement project (Neal et al., 2012; Tkach et al., 2023; Turkelson et al., 2020).

Tkach et al. (2023) surveyed 184 practicing CRNAs to assess their knowledge of ASRA's 2020 LAST treatment guidelines. The two most significant findings were that 23% of CRNAs reported a lack of immediate guideline access, and only 2.7% correctly identified four medications to be avoided in LAST. Administration of beta-blockers or calcium channel blockers decreases contractility of the heart and can potentiate the already life-threatening symptoms of LAST (Macfarlane et al., 2021). It is important to note that this study only had a 6% response rate. The authors concluded that cognitive aids should be accessible in every operating room to better equip anesthesia providers to manage this event. A major reference that Tkach et al. (2023) cited in their research was the study from Neal et al. (2012), which described using a checklist in LAST simulations.

Neal et al. (2012) completed a randomized control trial (Level II), which is the highest level of evidence, that supported using a quick reference guide for LAST. In the study, one group using the ASRA checklist and the other without the checklist were placed in a simulation of a patient developing LAST. Results demonstrated that those with the checklist had superior situational awareness, decision-making, management, and adhesion to guidelines when compared to those without the checklist. Specifically, lipid emulsion therapy was administered more accurately when providers had access to the ASRA checklist. It is generally recommended that hospitals encourage the use of visual aids or checklists for LAST (Macfarlane et al., 2021; Neal et al., 2012).

Turkelson et al. (2020), in a quasi-experimental study, examined the impact of developing and implementing a checklist for rare, high-risk conditions concerning safety, patient outcomes, and adherence to guidelines. Use of checklists was associated with sustainable clinically relevant improvements in care and practitioner self-confidence in caring for highly specific patient populations. Critical care processes and time efficiency were improved with use of checklists (Turkelson et al., 2020). The most significant finding demonstrated that using a checklist reduced errors in both simulated and clinical settings.

Project Framework

In designing this quality improvement project we followed the Institute for Health Care Improvement (IHI, 2023) model for improvement by implementing a plan-do-study-act (PDSA) quality improvement cycle. The PDSA cycle provided a framework for implementing change on a small scale, analyzing results from the change, and looking for future modifications. The project plan was to implement a quick reference guide for CRNAs to prevent, diagnose, and treat LAST in the operating rooms of the partnering institution (“Plan” phase). The project took place

in the operating rooms of the partnering institution over two weeks, where data was obtained via pre- and post-implementation questionnaires sent to the CRNA participants via Qualtrics surveys ("Do" phase). The questionnaire responses were analyzed to determine the outcomes and compare them to the predictions ("Study" phase). After data analysis, modifications to the implementation process and suggestions for future PDSA cycles were noted ("Act" phase).

Ethical Considerations and Protection of Human Subjects

The project population consisted of practicing CRNAs. There were no patients included. The project tool benefits everyone in the target population equally and equitably. Since the project is based on implementing a quick reference guide, there were no risks greater than what the CRNAs would experience on a given day. In preparation for the project, the project lead and author of this paper obtained additional education through Collaborative Institutional Training Initiative (CITI) modules: *Social and Behavioral Research Investigators and Key Personnel*. The CITI modules can be found online at https://about.citiprogram.org/. The project approval process was twofold. First, the project was screened by the East Carolina University College of Nursing's project review process. The screening process is a collaboration between the College of Nursing and the partnering institution's institutional review board (IRB). The College of Nursing screening determined that the project should fall within the realm of quality improvement. Second, the project was then submitted for facility approval through the University Medical Center Institutional Review Board (UMCIRB) in conjunction with the research office of the partnering institution. Lastly, local facility approval from the partnering institution was obtained via a signed letter of acknowledgment of project implementation by the clinical contact person (Appendix D).

Section III. Project Design

Project Setting

The partnering institution is a 974-bed, Level I trauma center where providers care for individuals across 29 counties. The institution is a teaching hospital with over 30 operating rooms and is partnered with the local university's school of medicine and college of nursing. The partnering institution is less than a mile from the university, which facilitates ease of implementation of the tool for the quality improvement project. Additionally, introduction of new educational reference guides is generally well accepted and adapted into practice at this teaching hospital.

Project Population

CRNAs were the target population for the implementation of the quick reference guide. Specifically, the project targeted CRNAs who work with local anesthetic medications. Because local anesthetics are so widely used in the peri-operative setting, the target population included all actively practicing CRNAs at the partnering institution. Many of the practicing CRNAs at the partnering institution obtained their degree from the partnering university and are familiar with the student-led quality improvement projects, which may have helped facilitate the project's implementation. However, there are many CRNAs with extensive experience that may have been less inclined to change their current practice because of their prior clinical successes. This could be perceived as a barrier to change. Alternatively, they may welcome the opportunity to inform their practice processes.

Project Team

The project team included the student registered nurse anesthetist (SRNA) project lead, three SRNA project team members, three faculty members, and a clinical site contact. The

SRNAs created the quick reference guide (Appendix E) and the pre-implementation and post-implementation survey questions as a group. Each SRNA was assigned to a different project setting for independent implementation, data collection, and analysis. The implementation, data collection, and analysis of this project was completed independently by the project lead and author of this paper. The project chair, a CRNA and former director of the Nurse Anesthesia Program, provided guidance for the framework of the project and final approval for the project details. Additionally, the project chair provided insight on quality improvement and standards of operation at the partnering facility. The program director, a CRNA, assigned the SRNAs to their respective project implementation setting and also served in the role of the clinical contact person. The program director functioned as the clinical contact and communicated with the partnering facility and identified CRNAs at the facility willing to participate in the project. The site contact person signed the letter of acknowledgement for data to be collected on that unit of the hospital (Appendix D). The course director provided guidance through each step of the project, being constantly available to answer questions or serve as an educational resource for the project.

Methods and Measurement

The purpose of the project was to assess CRNA perceptions of the adequacy of a LAST quick reference guide to assist in identifying, diagnosing, and treating patients at risk for developing LAST. The goal for the project was improved CRNA confidence in preventing, identifying, and treating LAST. The intervention was the implementation of a quick reference guide that contained information about the mechanism of action of local anesthetics, maximum dosages of local anesthetics, identification of high-risk administration of local anesthetics, in addition to the pathophysiology, signs and symptoms, and ASRA checklist for the treatment of

LAST (Appendix E). The quick reference guide was delivered via email to participants (Appendix F), and laminated copies of the quick reference guide were given to the participants to have in the operating room. Extra laminated copies of the QRG were placed in the anesthesia workroom at the partnering institution for CRNAs to use at will. QR codes were also available to be scanned to show a digital copy of the QRG. The data was collected through participants responses to pre-implementation and post-implementation surveys sent via Qualtrics (Appendix G).

The project began with meeting the project chair to identify and discuss an organizational need for quality improvement with the partnering institution. A PICOT question was formed, which helped to guide future literature searches to find supporting evidence for the topic and plan. The IHI Toolkit was completed, which included the PDSA Cycle, Cause and Effect Diagram, and Driver Diagram, to begin to visualize the framework for the quality improvement project (IHI, 2022).

The project chair guided the SRNAs on the development of problem and purpose statements, suggesting potential search strategies (Appendix A). A literature search was conducted to identify sources that would be retained for full-text review and potential use within the project (Appendix B). Used as support for the need and intervention, the articles that were retained after the full-text review were included in the literature matrix where each article underwent analysis to determine level of evidence and validity (Appendix C). The SRNAs gathered the pertinent peer-reviewed, evidence-based information for preventing, diagnosing, and treating LAST and included it in a quick reference guide that would serve as the implementation tool for the project (Appendix E).

After the project framework was determined, the project went through the approval process. The project was described in detail and sent into the partnering university's College of Nursing Institutional Review Board to determine if the project met quality improvement standards (Appendix D). Additionally, documentation about the project was submitted to the University Medical Center Institutional Review Board (UMCIRB) in conjunction with the research office of the partnering institution for facility approval (Appendix D).

Once project approval was obtained, participating CRNAs on faculty with the partnering medical facility were emailed a pre-implementation survey via Qualtrics (Appendix F). With the survey, the participants were emailed a copy of the LAST quick reference guide to be used over the course of the following few weeks (Appendix E). At the end of the pre-determined timeframe for intervention, participants were emailed a post-implementation survey via Qualtrics (Appendix F). Collection of survey responses maintained the confidentiality of participants.

Data collected from responses to surveys was mostly nominal with one free response for participants to share their thoughts about the reference tool. The data was compiled and analyzed to assess the usefulness with respect to CRNA confidence in preventing, identifying, and treating LAST. Additional comments or suggestions were used to consider future research or quality improvement with this topic.

Section IV. Results and Findings

Results

The purpose of the project was to assess the CRNA perceptions of the adequacy of the LAST QRG in assisting to identify high-risk patients and quickly diagnosing and treating LAST. To determine this, pre-implementation and post-implementation questions were emailed to participants in the form of Qualtrics surveys. The results were analyzed using Excel. The emails with the pre-implementation surveys, that also included the QRG and a brief PowerPoint presentation, were sent out and results were received over a two week period. Similarly, the emails with the post-implementation surveys were sent out and results were received over a two week period (Appendix F).

Of ten participants, four answered the pre-implementation survey, and four answered the post-implementation survey. One of the four participants had five-to-ten years of experience, while the other three participants had one-to-four years of experience as a CRNA. The survey questions included demographics, patient exposure, local anesthetic use, and prevention and treatment of LAST (Appendix G).

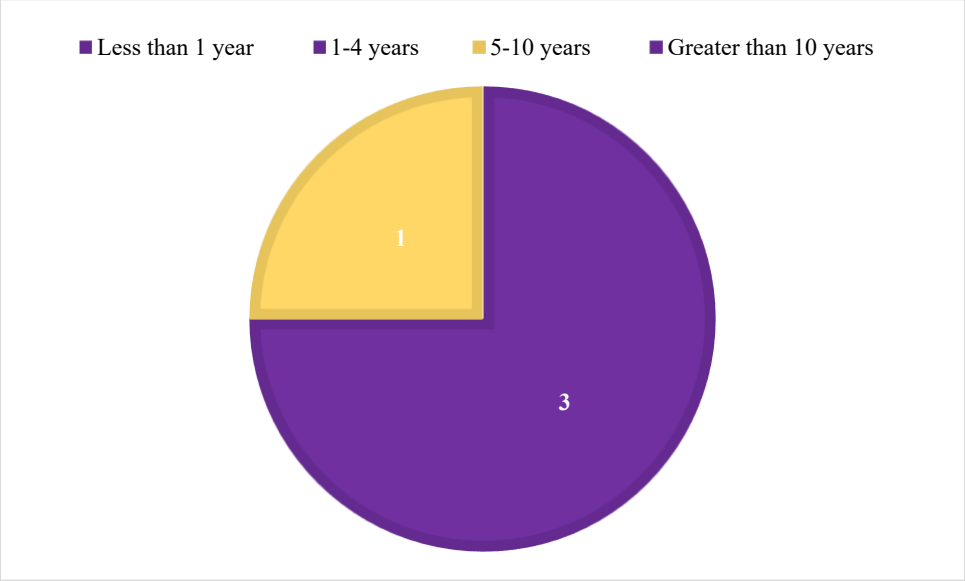
Data Presentation

The pre-implementation survey assessed how often the project participants cared for patients receiving local anesthetics in daily practice, and all four participants answered *daily*. The range practice experience of the participants can be seen in Figure 1. Several questions of the pre-implementation survey assessed the participants' familiarity and confidence with identifying LAST, identifying high risk patients, and diagnosing LAST. Two of four participants responded *very familiar* with LAST, and two selected *moderately familiar* with LAST. Two of four participants responded *very confident* in identifying high risk populations, one selected

moderately confident, and one *somewhat confident*. One of four respondents selected *very confident* in the diagnosis of LAST, two *moderately confident*, and one *somewhat confident*. Another question addressed the "BICEPSS" mnemonic for assessing risk factors for LAST, one of four participants selected *very familiar* with the mnemonic, one *moderately familiar*, one *somewhat familiar*, and one *not familiar* at all. Two of four participants reported they were *very confident* with lipid emulsion therapy as treatment for LAST, and two reported they were *somewhat confident*. Two of four participants selected *very familiar* with the location of intralipids in their facility, one *moderately familiar*, and one *somewhat familiar*.

Figure 1

Years spent practicing as a CRNA (n=4)

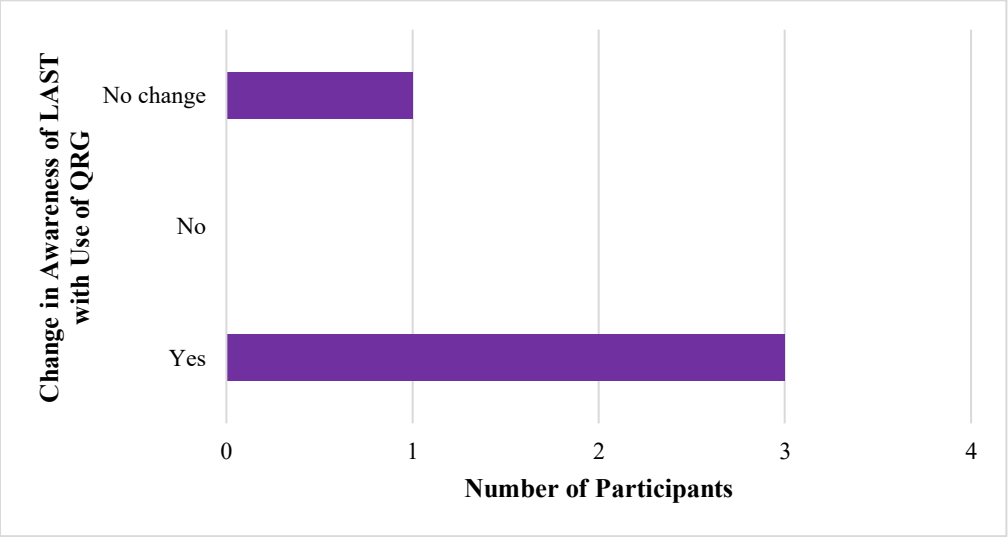


The first two questions of the post-implementation survey addressed the frequency of local anesthetic usage and the identification of high risk individuals. Three of four participants reported they had *six to ten cases* using local anesthetics in their previous two weeks, and one of four reported *greater than fifteen cases* using local anesthetics in the previous two weeks. All four participants identified *one to five* patients at high risk for developing LAST during a case

that used local anesthetics in the previous two weeks. The survey assessed the usefulness of the "BICEPSS" mnemonic in identifying regional use at high risk for developing LAST. Three of four participants found the mnemonic to be *very useful*, and one of four participants found the mnemonic to be *somewhat useful*. Two questions assessed if the QRG improved the participants' awareness and confidence in diagnosing and treating LAST. Three of four participants selected *improved awareness*, while one reported *no change,* as seen in Figure 2. Two of four participants selected *very confident* in diagnosing and treating LAST with access to the QRG, and two *moderately confident*. One question assessed if participants supported the implementation of the QRG at their facility. Two of four participants selected *strongly supported*, one *supported*, and one *neutral* on the implementation of the QRG at the facility. The last question of the post-implementation survey was an open ended question asking participants for recommendations about ways to improve the QRG. This question received no responses.

Figure 2

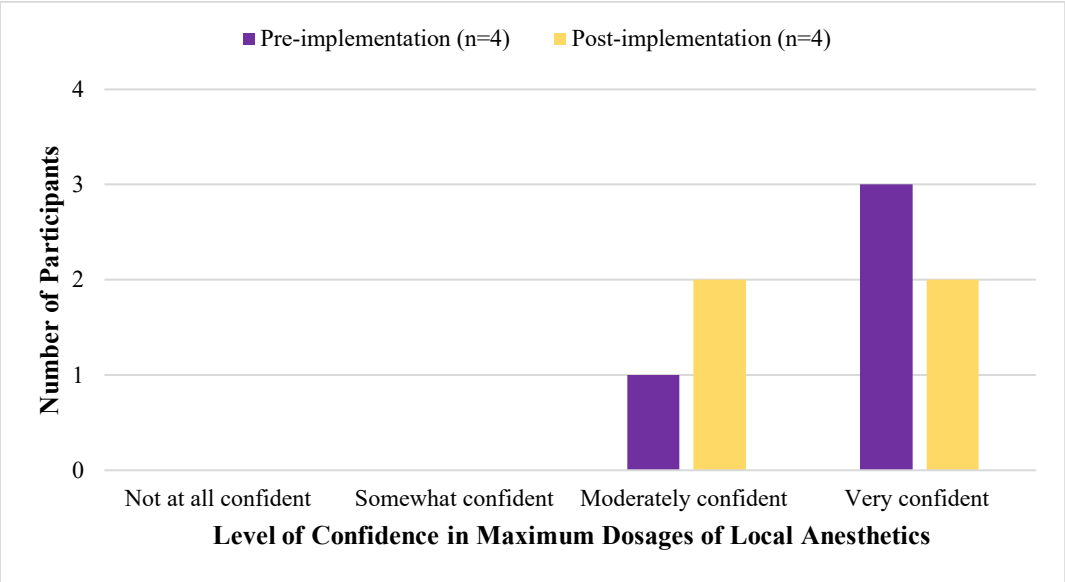
Assessment of participant change in awareness of LAST with the QRG (n=4)



Several questions were asked in the pre-implementation survey and then reassessed in the post-implementation survey. Multiple questions assessed knowledge of the lipid emulsion therapy (LET) as treatment for LAST. All four participants correctly identified the second mechanism of action of LET as a *positive inotropic agent* in the pre-implementation survey. Three of four participants correctly identified *positive inotropic agent* as the second mechanism of action, and one incorrectly identified *DNA synthesis inhibitor* as the second mechanism of action in the post-implementation survey. One of the later questions in the pre-implementation survey assessed confidence of participants' knowledge of the maximum dosages of the commonly used local anesthetics, with three of four responding *very confident* and one *moderately confident*. In the post-implementation survey, two of four participants responded *very confident* in their knowledge of maximum dosages, and two *moderately familiar* with their knowledge of maximum dosages. These results can be seen in Figure 3. The pre-implementation survey assessed participants' familiarity with medications to avoid in the treatment of LAST. For this question, two of four selected *very familiar* with drugs to avoid, and two *somewhat familiar*. The post-implementation survey reassessed the participants' familiarity with the drugs to avoid during LAST; two of four participants selected *very familiar* with the drugs to avoid, one *moderately familiar*, and one *somewhat familiar* with which drugs to avoid.

Figure 3

Confidence level of maximum dosages of local anesthetics (specifically bupivacaine, ropivacaine, and lidocaine), with and without epinephrine



Analysis

One interesting finding was from the pre- and post-implementation questions assessing the mechanism of action of lipid emulsion therapy. In the pre-implementation survey, all four participants correctly identified the secondary mechanism of action as a positive inotropic agent, but in the post-implementation survey there was one incorrect response. This dropped the response accuracy from 100% to 75% (n=4). A similar occurrence was found when asking about the confidence in knowledge of maximum dosages of commonly used local anesthetics in the pre- and post-implementation surveys. The majority of participants (three) reported being *very confident* of the maximum dosages in the pre-implementation survey, but the number dropped to only two participants selecting *very confident* in the post-implementation survey. These results could be due to an immense amount of information on the QRG, a discrepancy between previous

knowledge and what was learned from the QRG, or more likely the possibility of having different participants in the pre- versus post-implementation surveys. The Qualtrics surveys were sent out via anonymous links, so there is no way of knowing if the same four participants responding to the pre-implementation survey also responded to the post-implementation survey.

Overall, the QRG seemed to be a positive addition to practice for the participants. Three of four participants reported that the QRG improved their awareness of LAST in their daily practice. The responses for the ability to treat LAST with access to the QRG ranged from *moderately confident* to *very confident*. The majority of participants supported the addition of the QRG in practice at their facility. Based on the answers to the pre-implementation survey alone, the participants' baseline confidence in knowledge on the prevention and treatment of LAST was high. Though the responses were from a small pool of participants, the data collected could help guide future projects.

Section V. Implications

Financial and Nonfinancial Analysis

When a patient develops LAST within a hospital or institution, there is a potential for significantly increased costs of care related to extra time in the hospital and needing a higher level of care for treating this preventable condition. From an article published in 2015, the average cost of one day in the ICU is anywhere from $2,500 to upwards of $10,000 (Gershengorn et al., 2015). Since this article was published ten years ago, it is likely that the cost of additional time in the ICU is much higher than this estimate. Incorporating a low-risk tool, such as the QRG developed for this project, would incur little cost to the organization while potentially reducing LAST incidence to ensure the cost of care is not unnecessarily increased.

Since this project was developed and the QRG was designed by students, the initial costs of the project would be free to the institution. The QRG would likely belong to the anesthesia providers, who would be responsible for keeping up with current research and updating the QRG as practice changes. However, the time to search the literature and update the QRG would require time outside of the operating room. Thus, the anesthesia provider would need time away from current work duties. If done in an efficient manner, this cost would still be relatively low.

The QRG would bring quality improvement, quality assurance, efficiency, and potentially reduced hospital costs due to increased awareness and preparedness in preventing and treating LAST, should it occur. If the project was sponsored by the organization, it could have a great return on investment. There is little to no risk in adopting the QRG into everyday practice and potentially a very high reward with decreasing the incidence of LAST at the institution. Patient experience and satisfaction could be improved with the decreased incidence of this condition. The net benefit of increasing awareness of LAST and improving CRNA confidence in

caring for patients at risk for LAST decreases the likelihood of hospitals paying out of pocket for unexpected additional hospital days or ICU admissions from a preventable condition such as LAST.

In terms of sustainability, the project would be easily affordable by the organization. To develop a QRG or visual aid for the prevention and treatment of LAST, a committee of CRNAs or nurses would need to compile the information in an easy to read format which would take time and effort on behalf of the paid staff. Because of this quality improvement project, the students compiled the information and created the QRG with no cost to the institution. For the student, the cost was $25 for eight laminated copies of the QRG. However, it is free to access an online PDF or generate a QR code that can be scanned with a cell phone to access the online version of the QRG.

Implications of Project

As mentioned earlier, the American Society of Regional Anesthesia's mission statement is "to advance the science and practice of regional anesthesia and pain medicine to improve patient outcomes through research, education, and advocacy" (ASRA, 2014; Neal et al., 2020). Using the checklist for the treatment of LAST from ASRA would show commitment to patient safety by the partnering institution. The implementation of the QRG has positive implications for patient experience, quality improvement, and patient safety in the implementation setting.

The literature strongly supports the use of visual aids or references in practice areas of medicine. Tkach et al. (2023) recommended that cognitive aids should be readily accessible in every operating room for improved provider management of LAST. Tkach et al. (2023) cited the study from Neal et al. (2012), which used a checklist in LAST simulations in a randomized control trial. Results demonstrated that the providers and students with the checklist had superior

situational awareness, decision-making, management, and adhesion to guidelines when compared to those without the checklist, ultimately supporting a quick reference guide for LAST in practice. Turkelson et al. (2020), in a quasi-experimental study, examined the impact of developing and implementing a checklist for rare, high-risk conditions concerning safety, patient outcomes, and adherence to guidelines that was associated with sustainable clinically relevant improvements in care and practitioner self-confidence in caring for highly specific patient populations. The most clinically significant and important finding from the study demonstrated that using a checklist or visual aid reduced errors in patient care, whether simulated or clinical. All three of these articles were further supported by the project finding of improvement in awareness of LAST with the QRG available digitally and physically. The QRG made the ASRA guidelines for the treatment of LAST easily accessible to the participants of this study.

Sustainability

Most practicing CRNAs find reference material online or from saved information on their phones, so an online copy of the QRG uploaded to a central document-sharing location for the hospital anesthesia providers would make it easily accessible and at no cost. The anesthesia providers would need to be aware of the newly added QR codes for the QRG or the upload of the QRG to the central document-sharing location, which could occur via email or in a regular mandatory institutional staff meeting.

Further quality improvement projects might be needed to support the implementation of the project. As mentioned earlier, four of ten participants engaged and responded to the pre- and post-implementation surveys. Due to the small sample size from the project, further quality improvement projects with a larger sample sizes would be beneficial to support adding a QRG for the prevention and treatment of LAST into practice. Additional quality improvement projects

could benefit from a team including the hospital's quality improvement personnel partnering with members within the anesthesia group. The quality improvement personnel could collaborate with anesthesia group members whose expertise and commitment could greatly strengthen the implementation process, leveraging their dedication to patient care to enhance project outcomes.

Dissemination Plan

This project's principle investigator members created and presented a poster about the project to the nurse anesthesia department members. The unique findings were presented to the Nurse Anesthesia Program's faculty, College of Nursing faculty, and students. Additionally, the final version of this paper and poster will be published to The Scholarship, the East Carolina University digital repository, which is available to the public.

Section VI. Conclusion

Limitations

The limitations to the project can be divided into planning, implementation, and evaluation limitations. During the planning phase, the author of this paper received the list of participants the night before the implementation start date. With the lack of time to prepare for implementation with this specific list, the author would have benefited from more time. The implementation phase limitation was leaving the laminated QRGs in a central location for the CRNAs to use on the starting day of implementation. At the end of the implementation time, the author found the laminated copies where they were left at the beginning of the project. Therefore, the use of the laminated copies of the QRGs is undetermined. Ten participants were selected for the project, but only four responded to the pre-implementation and post-implementation surveys, respectively. This data analysis was insufficient for statistical significance due to the small participation numbers, however clinical significance was still found. If all ten participants had responded to the pre- and post-implementation surveys, the number would remain too small for statistical significance in data analysis. The results were sent out via anonymous links, so the discrepancy between some of the pre- and post-implementation could be due to the possibility of the four that responded to the pre-implementation survey were not the same four that responded to the post-implementation survey. Suggestions for addressing the limitations mentioned above will be discussed in the next section.

Recommendations for Future Implementation and/or Additional Study

The author recommends additional study, whether it is the same project on a larger scale or as a project that builds on this one. If another organization wanted to do the same project, then this project could be a model. The author of this paper offers recommendations in the areas of

planning, implementation, and evaluation based on the execution of this project. It is recommended to have the implementation dates and names of participants in advance so that implementation is not hurried. The organization could consider including where the intralipid is stored at that institution on their QRG. For implementation, presenting the information in person in a conference setting prior to implementing the project may result in a higher number of active participants. It is recommended that laminated copies of the QRG be placed in every operating room or where local anesthetics are being used because seeking out a visual aid in a central location may not be convenient. A more attentive line of communication to remind participants to respond to the surveys may have also resulted in higher response rates results. Additionally, making the surveys confidential instead of anonymous would allow for tracking which participants took the survey and those who did not, which may potentially increase participation through sending intentional reminders. All of these changes could improve the project and could potentially improve patient outcomes on a larger scale.

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Appendix A

Literature Concepts Table

	Concept 1 *Perioperative*	Concept 2 *Local Anesthetic Systemic Toxicity (LAST)*	Concept 3 *Reference Tool*	Concept 4 *CRNA*
Keywords	Periop Perioperative	Local Anesthetics Local Anesthetic Toxicity Local Anesthetic Systemic Toxicity LAST	Reference Tool Reference Guide	CRNA Nurse Anesthetist Certified Registered Nurse Anesthetist
PubMed MeSH	("Perioperative Period"[MeSH Terms] OR "Perioperative Care" [MeSH Terms] OR "Perioperative Medicine" [MeSH Terms])	("Anesthetics, Local" [MeSH Terms] OR "Anesthetics, Local/Toxicity" [MeSH Terms])	"Resource Guide" [MeSH Terms]	"Nurse Anesthetist" [MeSH Terms]
CINAHL Subject Headings	(MH "perioperative care") OR (MH "perioperative medicine")	(MH "Anesthetics, Local") OR (MH "Anesthetics, Local/Adverse Effects")	MH "Reference Tool"	MH "Certified Registered Nurse Anesthetists"
Google Scholar	Periop OR Perioperative	Local Anesthetics OR Local Anesthetic Toxicity OR Local Anesthetic Systemic Toxicity OR LAST	Reference Tool OR Reference Guide	CRNA OR Nurse Anesthetist OR Certified Registered Nurse Anesthetist

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
9/11/24	PubMed	(local anesthetic systemic toxicity AND perioperative) (("anesthetics local"[Pharmacological Action] OR "anesthetics, local"[MeSH Terms] OR ("anesthetics"[All Fields] AND "local"[All Fields]) OR "local anesthetics"[All Fields] OR ("local"[All Fields] AND "anesthetic"[All Fields]) OR "local anesthetic"[All Fields] OR "anesthesia, local"[MeSH Terms] OR ("anesthesia"[All Fields] AND "local"[All Fields]) OR "local anesthesia"[All Fields]) AND ("systemic"[All Fields] OR "systemically"[All Fields] OR "systemics"[All Fields]) AND ("toxic"[All Fields] OR "toxical"[All Fields] OR "toxically"[All Fields] OR "toxicant"[All Fields] OR "toxicant s"[All Fields] OR "toxicants"[All Fields] OR "toxicated"[All Fields] OR "toxication"[All Fields] OR "toxicities"[All Fields] OR "toxicity"[MeSH Subheading] OR "toxicity"[All Fields] OR "toxicity s"[All Fields] OR "toxics"[All Fields]) AND ("perioperative"[All Fields] OR "perioperatively"[All Fields])) AND ((y_5[Filter]) AND (fft[Filter]))	Last 5 years (2019-2024) English Peer-Reviewed	4 kept/46 found (reviewed 5 pages of results)	Case studies, not applicable Use of local anesthetics, no focus on LAST Kept articles that discussed prevention, treatment, and knowledge of LAST

9/12/24	CINAHL	(MH "Drug Toxicity") AND (MH "Anesthetics, Local")	Last 5 years (2019-2024) English Peer-Reviewed	5 kept/8 found (reviewed 1 page of results)	Case studies, not applicable Settings outside of perioperative settings, not applicable
9/12/24	Google Scholar	(local anesthetic systemic toxicity) AND (CRNA) AND (perioperative setting)	Last 5 years (2019-2024) English Peer-Reviewed	12 kept/578 found (reviewed 5 pages of results)	Case studies, not applicable Many of the results did not apply based on topic

Appendix C

Literature Matrix

Year	Author, Title, Journal	Purpose & Conceptual Framework or Model	Design and Level of Evidence	Setting	Sample	Tool/s and/or Intervention/s	Results
2023	Lee, S. H. & Sohn, J. (2023). Mechanisms underlying lipid emulsion resuscitation for drug toxicity: A narrative review. *Korean Journal of Anesthesiology, 76*(3), 171-182. https://doi.org/10.4097/kja.23031	To provide the underlying mechanisms of lipid emulsion resuscitation during LAST and description of treatment Conceptual framework/model: none noted	VII: narrative literature review	Labs, clinics, hospitals	Animal, clinical experiments, case reports, letters, reviews, articles relevant to LAST	PubMed search	MOA: Lipid emulsion therapy has a lipid shuttle effect which shuttles local anesthetics away from high blood flow organs (heart, brain) to detoxifying and storing organs (liver, muscle, fat). It also has a positive ionotropic effect on the heart "the underlying mechanisms of LE resuscitation used for the treatment of toxicity caused by local or non-local anesthetic drugs, include the lipid shuttle (LE-mediated binding and enhanced redistribution), positive inotropic effects, fatty acid supply, attenuation of mitochondrial dysfunction, glycogen synthase kinase-3β phosphorylation, and attenuation of NO production." P.178
2023	Tkach, L., Baillie, L., Newby, J., O'Guin, C., Dalley, C. B., Crowell, N., & Eshkevari, L. (2023). Assessing CRNA knowledge of local anesthetic systemic toxicity. *AANA Journal, 91*(5), 385-390.	To assess CRNA knowledge of 2020 ASRA LAST treatment guidelines Conceptual framework/model: none noted	VI: descriptive study	Hospital	184 practicing CRNAs, active members of AANA	Electronic survey De novo data collection tool to assess CRNA knowledge of LAST	23% reported lack of immediate guideline access Only 2.7% correctly identified all 4 meds to be avoided in LAST **"Anesthesia trainees utilizing an ASRA checklist for a simulated LAST scenario**

							demonstrated superior management when compared with their non-checklist peers" p. 389 **"By providing cognitive aids such as posters, checklists, and emergency manuals in every operating room, CRNAs and other anesthesia providers will be better equipped to address LAST."** P.389
2021	Macfarlane, A. J., Gitman, M., Bornstein, K. J., El-Boghdadly, K., & Weinberg, G. (2021). Updates in our understanding of local anaesthetic systemic toxicity: a narrative review. *Anaesthesia, 76*(1), 27-39. https://doi.org/10.1111/anae.15282	To illustrate the fundamentals of LAST: mechanisms, prevention, diagnosis, and treatment Conceptual framework/model: none noted	VII: narrative literature review	Hospital	36 cases of LAST reported in 34 peer-reviewed published articles	Reviewed setting, type of block, dose, administration, and treatment of LAST occurrences	"1.8 per 1000 nerve blocks" p.28 "Regional anesthesia using local anesthetics will always require awareness of LAST, since the risk cannot be eliminated altogether, even with perfect practice." P.37
2019	Gitman, M., Fettiplace, M., Weinberg, G., Neal, J., & Barrington, M. (2019). Local anesthetic systemic toxicity: A narrative literature review and clinical update on prevention, diagnosis and management. *American Society of Plastic Surgeons, 144*(3), 783-795. https://doi.org/10.1097/PRS.0000000000005989	To provide an update on prevention, diagnosis, and management Conceptual framework/model: none noted	VII: narrative literature review	Labs, clinics, hospitals	Human and animal studies and case reports in last 50 years	MEDLINE search	"Diagnosis of local anesthetic systemic toxicity may be obscured by perioperative processes, sedation, and general anesthesia or be wrongly attributed to patient comorbidities." P.786 **"Management of local anesthetic systemic toxicity should include the use of cognitive aids such as checklists or an electronic decision support tool."** P. 790
2012	Neal, J. M., Hsiung, R. L., Mulroy, M. F., Halpern, B. B., Dragnich, A. D., & Slee, A. E.	To test the hypothesis that anesthesia trainees with the ASRA	II: RCT	Medical institution	Clinical anesthesia, residents,	Simulation of treating patient with LAST – one group	Results: **"The full-use group demonstrated superior situation awareness, decision making,**

	(2012). ASRA checklist improves trainee performance during a simulated episode of local anesthetic systemic toxicity. *Regional Anesthesia and Pain Medicine, 37*(1), 8-15. https://doi.org/10.1097//AAP.0b013e31823d825a	checklist would perform better in a LAST scenario than their no-checklist counterparts To assess the usability and readability of the checklist Conceptual framework/model: none noted			regional anesthesiology and acute pain medicine fellows All had ACLS	with checklist, one without	**and total scores on the ANTS assessment."** P.12 "The checklist group significantly outperformed the no- checklist group as evidenced by higher scores on the 21-item post-checklist performance evaluation. Therefore, having the ASRA Checklist resulted in superior medical management of simulated LAST" p.11 "Lipid emulsion management was significantly more accurate when the ASRA Checklist was available." P.11 **"The ASRA Checklist provides an algorithm for the optimal management of LAST based on the Advisory's recommendations."** P.12 "In our study, trainees who used the ASRA Checklist demonstrated superior medical management of severe LAST compared with colleagues who did not receive the checklist. This result suggests that using the checklist may enhance medical management and patient safety during an actual clinical LAST event." P.12
2018	El-Boghdadly, K., Pawa, A., & Chin, K., J. (2018). Local anesthetic systemic toxicity: Current perspectives. *Local and*	To update the current understanding, treatment, and prevention of LAST	VII: expert opinion	Not identified	Not identified	Not identified	"Ultrasound has been shown to reduce the risk of LAST 60-65% as compared to peripheral nervous stimulation alone…

	Regional Anesthesia, 11, 35-44. https://doi.org/10.2147/lra.s154512	Conceptual framework/model: none noted					Increased accuracy of delivery permits reduction of volume and, therefore, dose of LA; the incidence of vascular puncture may be reduced; and visual cues signaling intravascular injection allow termination of injection before a significant dose is delivered." P. 41 (to be used in the reference tool) "**It is imperative that practitioners who use LA in their clinical practice are cognizant of the mechanisms, risk factors, prevention, and therapeutic modalities.**" P.42
2020	Turkelson, C., Keiser, M., Sculli, G., & Capoccia, D. (2020). Checklist design and implementation: critical considerations to improve patient safety for low-frequency, high-risk patient events. *BMJ Simulation & Technology Enhanced Learning, 2020*(6), 148-157. https://doi.org/10.1136/bmjstel-2018-000353	To develop and implement a checklist for low-frequency, high-risk patients and assess relationship to patient outcomes, safety, and adherence to practice guidelines Conceptual framework/model: none noted	III: quasi-experimental prospective pre-post repeated measure design	CICU	26 CICU nurses	10 crisis checklists, simulations, 5 point Likert scale pre and post implementation questionnaire	**"Overall self-confidence and self-confidence related to skills and knowledge while not significant demonstrated clinically relevant improvements that were sustained over time. Perceptions of the checklists were positive with consistent utilization sustained over time. More importantly, use of the checklists demonstrated a reduction in errors both in the simulated and clinical setting."** P.148 **Critical care processes, time efficiency, and reduction in patient errors were improved with the use of the checklists**

Note: Key to abbreviations used in chart:

AANA: American Association of Nurse Anesthesiology; LAST: local anesthetic systemic toxicity; ASRA: American Society of Regional Anesthesia and Pain Medicine; ACLS: Advanced Cardiovascular Life Support; LE: lipid emulsion; CICU: cardiac intensive care unit

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.

(Adapted from Brown, S. J. (2018) Evidence-based nursing: The research-practice connection. (3rd ed.). Jones & Bartlett Learning.)

Appendix D

Approval Process

[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.

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 [redacted] to obtain site support from [redacted].

Name of Project Leader:

Mary Pierce

Project Title:

Prevention and Treatment of Local Anesthetic Systemic Toxicity: A DNP Project

Brief description of Project/Goals:

The purpose of this quality improvement project is to assess anesthesia providers' perceptions of the adequacy of a newly developed quick reference guide for Local Anesthetic Systemic Toxicity (LAST). Process: A quick-reference perioperative guide, based upon accepted national guidelines, will be developed. Anesthesia providers at [redacted] will be asked several questions (through Qualtrics) about their perceptions of the adequacy of their currently used processes in their current practice. An educational video about the use of a newly developed quick-reference guide for LAST will be made available to them, and they will be asked about the use of the quick-reference guide 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 quick-reference guide for LAST 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 the 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

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. 11/18/2024

Human Subject Research Determination Form

This form should be completed and submitted for review by the service lines impacted by the work prior to project initiation (including, but not limited to, collection or analysis of baseline data). Projects that are "Not Human Subjects Research" are not required to submit an IRB application in ePirate. To help make that determination, you may utilize the Decision Chart provided by the Office for Human Research Protections along with this worksheet. For any project where there is a question as to whether it qualifies as Quality Improvement or Research, or if certification of "Not Human Subjects Research" is needed for publication, please route to the UMCIRB office via email: [redacted]

Please check the Office of Clinical Research Website or UMCIRB website to make sure that you have the most recent version of this form.

Project Title	Prevention and Treatment of Local Anesthetic Systemic Toxicity: A DNP Project
Project Leader	Mary Pierce
Project Leader Contact E-mail	Monroema22@students.ecu.edu
Department or Unit Affiliation	Anesthesia
Project Advisor (if applicable)[1]	Maura McAuliffe, PhD, CRNA, FAAN

Additional Faculty, Staff, and Trainees Involved (add more rows if needed):

Name	Department or Unit	Role	Check this box if this team member will access PHI or PII for the purposes of this project.
Courtney Dilao	Anesthesia	Student project team member	☐
Dalton Henderson	Anesthesia	Student project team member	☐
Cordelia Rios	Anesthesia	Student project team member	☐
			☐
			☐
			☐
			☐
			☐
			☐
			☐
			☐

[1] All student, resident, and fellow projects must have a faculty or unit leader designated as the advisor for the project.

Please answer the following questions to the best of your ability. If the answers to these questions change during the course of the project, please resubmit this form for review:

End Goal / Desired Outcome:

This Doctor of Nursing Practice (DNP) quality improvement project aims to assess Certified Registered Nurse Anesthetists' (CRNAs') perceptions of the adequacy of a newly developed cognitive aid regarding the prevention and treatment of local anesthetic systemic toxicity (LAST) and any impact it may have on their confidence in managing LAST. This project is relevant as it has been shown that cognitive aids showed improved patient outcomes and patient safety in the treatment of LAST. This project will be deemed successful if the newly developed cognitive aid is well-received and increases CRNA confidence in managing patients who have developed LAST. Knowledge gained from this project could be used in future quality improvement and policy efforts aimed at standardizing anesthesia care and increasing CRNA confidence in managing LAST.

Methodology / Intervention:

The project framework is a single Plan, Do, Study, Act (PDSA) cycle using a pre-and post-implementation survey design. During the *plan* phase, a cognitive aid addressing local anesthetic systemic toxicity (LAST) will be designed based on current national guidelines and accepted practice standards within the practice site and will address a project site need. CRNA participants will be recruited, and their participation will be voluntary. During the *do* phase, project participants will be contacted via email and asked to complete a pre-implementation survey, watch an informational PowerPoint Presentation, utilize/assess the project tool during the implementation period, and complete a post-implementation survey evaluating the project tool based on their perceptions of its applicability to their clinical practice and any impact it may have on their confidence in managing LAST. During the *study* phase, the project lead will analyze the data obtained from the pre- and post-implementation surveys to determine CRNA perceptions of the cognitive aid and any impact on their confidence in managing LAST. Knowledge gained from this project could be used in future quality improvement and policy efforts aimed at standardizing anesthesia care and increasing CRNA confidence in managing LAST.

Data to be collected:

Data will be gathered confidentially directly from participants through the completion of Qualtrics pre- and post-implementation surveys delivered and completed electronically. Qualtrics survey software is accessed through ECU and involves multifactorial password protection. The surveys will contain nominal, ordinal, and free response data. No PHI will be collected for this project.

Aside from participant emails, no identifiable data will be gathered. Data of interest are participant perceptions of the adequacy of the cognitive aid in clinical practice and any impact it may have on their confidence in managing local anesthetic systemic toxicity (LAST).

Once collected, the data will be transferred to Excel for deidentification and analysis. Data in Excel will be stored on a password-protected spreadsheet and laptop. The deidentified data will be analyzed with results shared via a poster presentation to the ECU Nurse Anesthesia Program students and faculty, with project participants invited to view the presentation remotely. If requested, a presentation of results to the participating department will be provided. Data will be stored in Qualtrics and Excel files (de-identified) until student graduation, anticipated to be in the spring of 2026. Additionally, the analysis of results will be discussed in a DNP Project Paper, the completion of which is required for program graduation. This paper will be posted in the ECU digital repository, The Scholarship.

Complete the following questions to guide leadership's determination of this project's status:

	True	False
The PRIMARY purpose of the proposed activity or project is limited to: - implementing a standard practice to improve the quality of patient care and to collect data regarding that implementation for clinical, practical, or administrative purposes, and/or - delivering healthcare and measuring and reporting provider performance data for clinical, practical, or administrative uses.	☒	☐
The activity or project would be carried out even if there was no possibility of publication in a journal or presentation at an academic meeting.	☒	☐
The activity or project falls under well-accepted care practices/guidelines and are designed to bring about immediate improvements in health delivery or quality of care. If "true" and the project is related to clinical activity, please provide a citation below as evidence that project activities fall within standards of care. Projects not directly related to clinical activity, such as medical education, do not need to provide a citation. Tkach, L., Baillie, L., Newby, J., O'Guin, C., Dalley, C. B., Crowell, N., & Eshkevari, L. (2023). Assessing CRNA knowledge of local anesthetic systemic toxicity. *AANA Journal, 91*(5), 385-390.	☒	☐
The activity or project involves "no more than minimal risk" procedures. (i.e., 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).	☒	☐

Please submit this form to your supervisor (or designee) for review and approval. Signature on this form certifies that that the below individual is in support of this project taking place and agrees with the project leader's answers to the above questions:

Supervisor's Name	Dewayne Byrd
Signature	Signed by: [redacted] 0704FC6E5DCA423...
Date	2/6/2025 | 11:15 PM EST

For Project Leaders: From the list below, please check the boxes for each service line where interventions may take place or where data may be collected. For each selected area, please route for signature for both the physician leader and administrator (preferably via DocuSign). Send a completed copy of the form to [redacted]

For Service Line Leaders: Signature on this form certifies that you are in support of this project taking place and agree with the answers to the above questions. If you are not in support of the proposed project, please discuss with the project leader, supervisor, and UMCIRB as needed.

	SERVICE LINE	SIGNATORY
☐	Adult Medicine (Medical Critical Care, Infectious Disease, Hospital Medicine, Pulmonology, Endocrinology, Allergy, Dermatology, & Nephrology)	Paul Bolin, MD
☒	Adult Surgical Service (Anesthesiology, Trauma, ENT, Benign Urology, Plastics, Ophthalmology, Transplant Surgery, & Acute Care Surgery)	Signed by: [redacted] Eric DeMaria, MD Signed by: [redacted] Wendy Leutgens, MSN
☐	Behavioral Health (Child / Adolescent Psychiatry, Behavioral medicine, & Adult Psychiatry)	Michael Lang, MD Todd Hickey, MHA
☐	Cancer (Breast cancer, Lung cancer, Gynecologic cancer, hematology, GI cancer, Urologic cancer, and Head & Neck cancer)	Emmanuel Zervos, MD Todd Hickey, MHA
☐	Children's Health (Pediatric Surgery, General Pediatrics, Well Newborn, Newborn & Pediatric Critical Care, Pediatric Hem-Onc, Neonatology, Pediatric medicine, Medicine subspecialities, surgical subspecialties)	Matthew Ledoux, MD Tara Stroud, DNP
☐	Emergency Services (Emergency Preparedness, Emergency Management, & Emergency Services)	Leigh Patterson, MD Debra Hernandez, MHA
☐	Heart & Vascular (Interventional Cardiology, Electrophysiology, Cardiac Surgery, Advanced Heart Failure, Cardiac Critical Care, Vascular Surgery, Cardio pulmonary rehab, Structural heart, & Thoracic Surgery)	Mark D. Iannettoni, MD Jay Briley, MHA

☐	Neuro Sciences (Neurology, Neurosurgery, Neuro Degenerative Disease, Neuro Critical Care, Stroke, Neuro Radiology, & Spine)	Stuart Lee, MD Jay Briley, MHA
☐	Nursing	Trish Baise, DNP
☐	Orthopedics (Joints, Orthopedic Surgery, Rheumatology, Sports medicine, Orthopedic medicine, & Orthopedic Trauma)	Deanna Boyette, MD Van Smith, MBA/MHA
☐	Pathology & Lab Services	Craig Steffee, MD Dave Harlow, PharmD
☐	Physical Medicine & Rehab (Rehab, Therapy (OT, PT, SLP), Pain, Wound Care, & Audiology)	Clint Faulk, MD Dave Harlow, PharmD
☐	Primary Care (Family medicine, Med-Peds, General Internal Medicine, Palliative Care, Geriatrics, & Sleep Medicine)	Jonathon Firnhaber, MD Dan Drake, PhD
☐	Radiology	Eric Martin, MD, PhD Dave Harlow, PharmD
☐	Women's Health (Gynecology, Obstetrics, & Maternal Fetal Medicine)	James Whiteside, MD Tara Stroud, DNP
☐	Projects that do not fit in the above service line areas	Niti Armistead, MD Brian Floyd, MBA

Optional Determination:
For any project where there is a question as to whether it qualifies as Quality Improvement or Research, or if certification of "Not Human Subjects Research" is needed for publication, please route to the UMCIRB office via email: [redacted]

☒ **Not Human Subjects Research:** The UMCIRB office has determined that based on the description of the project, approval by the IRB is not necessary. Any changes or modifications to this project may be discussed with the UMCIRB office at that time to ensure those changes do not elevate the project to human research that would need IRB approval.

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

UMCIRB Office Staff Signature: Signed by: [redacted] 05370E520AB34D3... **Date:** 4/3/2025 | 8:03 PM EDT

The UMCIRB office will contact you if any further information is needed to make this determination. Please note that if the UMCIRB office determines the activity is not human subjects research, then any presentation, publication, etc. should not refer to the activity as such.

Appendix E

Quick Reference Guide

ECU COLLEGE OF NURSING

Local Anesthetic Systemic Toxicity (LAST) Reference Tool

Cordelle G. Rios, BSN, RN, SRNA
Dalton Henderson, BSN, RN, SRNA
Courtney Dilao, BSN, RN, SRNA
Mary Elise Pierce, BSN, RN, SRNA
Dr. Maura McAuliffe, CRNA, PhD, FAAN, Project Chair

Physiology of LAST

The mechanism of action for most local anesthetics is the ***blockage of the sodium ion channel on nerve axons***, disrupting action potentials and blocking nerve signaling. In LAST, the ***plasma concentration of the local anesthetic increases and sodium channels in the brain and heart become blocked***. Prolonged blockade of sodium channels in the heart and brain leads to inhibition of oxidative metabolism and inhibition of mitochondrial activity. This puts the heart and brain into an anaerobic state. When in an anaerobic state, the following signs, and symptoms of LAST occur.

How to Prevent LAST Occurrence

- Understand **High Risk Populations and Risk Factors**
  - Extremes in age (very young & very old)
  - Low protein levels
  - Low muscle mass
  - Cardiac patients
  - Renal failure
- Understand the **Drug** Used
  - Type of LA (ester vs. amide)
  - Dose of LA
  - Volume of LA
- Utilization of **ultrasound (reduces risk by 60-65%)**
  - Increases accuracy, reduction in volume and dose of local anesthetic
- Knowledge of **anatomy** at site of injection
- Know **maximum doses** of local anesthetics (see chart)
- Incremental injection technique
- **Test dose** with epinephrine

Signs and Symptoms

- circumoral numbness
- tinnitus
- confusion
- dizziness
- disorientation
- visual and auditory disturbances
- agitation
- **seizures**
- arrhythmias
- hypotension
- conduction disturbances
- cardiac arrest

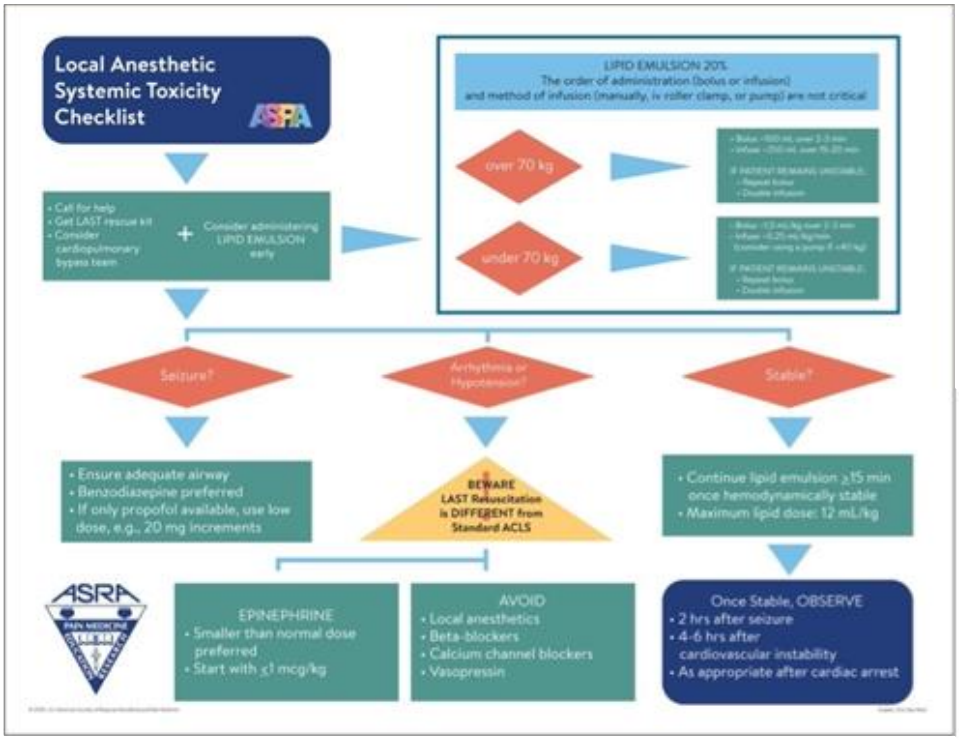
CNS signs and symptoms are more common than CV. **Seizures is the MOST common.**

Maximum Recommended Doses of Local Anesthetics

Medication	Regular	with Epi
Lidocaine	**3-4.5mg/kg**	**6-7mg/kg**
Mepivacaine	4.5-5mg/kg	7mg/kg
Bupivacaine	**2.5mg/kg**	**3mg/kg**
Levobupivacaine	2mg/kg	2mg/kg
Ropivacaine	**2.5mg/kg**	**3mg/kg**
Chloroprocaine	10mg/kg	15mg/kg
Procaine	8mg/kg	10mg/kg
Prilocaine	5-6mg/kg	7.5-8mg/kg

MOA of Lipid Emulsion Therapy

Lipid emulsion therapy has two functions: it's greatest MOA is from the function of a ***lipid shuttle*** – transporting the local anesthetics from an area of high-flow organs (heart and brain) to detoxifying organs (muscles, fat, liver). Additionally, lipid emulsion therapy has a ***positive ionotropic effect on the heart*** (El-Boghdadly et al., 2018).



Remember "BICEPSS" = Order of Blocks at Highest Risk of LAST

B = blood/bronchial
I = intercostal
C = caudal
E = epidural
P = plexus (brachial)
S = sciatic
S = subcutaneous

Reference

El-Boghdadly, K., Pawa, A., & Chin, K. J. (2018). Local anesthetic systemic toxicity: current perspectives. Local and regional anesthesia, 11, 35-44. https://doi.org/10.2147/LRA.S129511

Keddis R.N. (2013). Chapter 120. Local anesthetics and adjuvants. Atchabahian A, & Gupta R[Eds.], The Anesthesia Guide. The McGraw-Hill Companies. https://accessanesthesiology.mhmedical.com/content.aspx?bookid=571&sectionid=42567709

Neal, J. M., Neal, E. L., & Weinberg, G. L. (2021). American Society of Regional Anesthesia and Pain Medicine local anesthetic systemic toxicity checklist: 2020 version. Regional Anesthesia and Pain Medicine, 46(1), 81-82. https://doi.org/10.1136/rapm-2020-101986

Appendix F

Participant Emails with Links to Intervention and Qualtrics

Initial Pre-Survey and Video Email to Participants (1)

Dear [redacted] CRNAs,

Thank you for considering participating in a quality improvement project titled "Prevention and Treatment of Local Anesthetic Systemic Toxicity: A DNP Project." The purpose of this project is to assess CRNA perceptions of the adequacy of a LAST Quick Reference Guide designed to assist in identifying high-risk patients to quickly diagnose and appropriately treat LAST at [redacted]

Participation is voluntary and will involve completing a short pre-implementation survey, viewing a brief video, utilizing a LAST Quick Reference Guide in your CRNA 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 the LAST Quick Reference Guide 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 provide link here.

Following completion of the survey, view the PDF of the LAST Quick Reference Guide.

Again, thank you for your participation in our quality improvement project. I will be at [redacted] from March 11th to April 30th if you have any questions, You may also reach out to me or Dr. Maura McAuliffe by email at any time.

Sincerely,

Mary Pierce, SRNA monroema22@students.ecu.edu
Maura McAuliffe, PhD, CRNA, FAAN mcauliffem@ecu.edu

Pre-Survey and Video Reminder Email to Participants (2)

Hello [redacted] CRNAs,

I just wanted to send a quick reminder about the ongoing DNP Project on the prevention and treatment of LAST (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. After the end of next week, I will begin sending out the post-surveys.

Links:
Pre-survey
Video/PPT (attached to this email)

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

Sincerely,
Mary Pierce, SRNA
ECU Nurse Anesthesia Program
Class of 2026

Post-Survey Email to Participants (3)

Dear [redacted] CRNAs,

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 attached to this email. It should only take 10 minutes of your time.

If you've already completed the first survey, please complete the post-survey at this link. 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 and for being excellent preceptors. I look forward to coming back to [redacted] soon.

Sincerely,
Mary Pierce, SRNA
ECU Nurse Anesthesia Program, Class of 2026

Final Thank You Email to Participants (4)

Dear [redacted] CRNAs,

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 LAST Quick Reference Guide and found it useful, you can continue to use it in your everyday practice!

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

Take care,
Mary Pierce, SRNA
ECU Nurse Anesthesia Program
Class of 2026

Appendix G

Pre- and Post-Implementation Surveys

Pre-Implementation Survey Questions:

1. How long have you been a practicing Certified Registered Nurse Anesthetist (CRNA)?
    a. Less than 1 year
    b. 1-4 years
    c. 5-10 years
    d. Greater than 10 years
2. How often do your patients receive local anesthetics (IV administration and/or regional) in your daily practice as a CRNA?
    a. Daily
    b. Weekly
    c. Monthly
    d. Rarely
3. How familiar are you with local anesthetic systemic toxicity (LAST)?
    a. Not at all familiar
    b. Somewhat familiar
    c. Moderately familiar
    d. Very familiar
4. How confident are you in identifying high risk populations for LAST?
    a. Not at all confident
    b. Somewhat confident
    c. Moderately confident
    d. Very confident
5. How confident are you in the diagnosis and treatment of LAST?
    a. Not at all confident
    b. Somewhat confident
    c. Moderately confident
    d. Very confident
6. Are you familiar with the mnemonic BICEPSS indicating blocks at highest risk of LAST?
    a. Not at all familiar
    b. Somewhat familiar
    c. Moderately familiar
    d. Very familiar
7. In addition to being a lipid shuttle, the second main mechanism of action of lipid emulsion therapy (LET) includes:
    a. Alpha receptor agonist
    b. Beta receptor antagonist
    c. Positive inotropic
    d. DNA synthesis inhibitor
8. How confident are you with dosing LET for treating LAST?
    a. Not at all confident
    b. Somewhat confident

    c. Moderately confident
    d. Very confident
9. How familiar are you with the location of lipid emulsion therapy storage in the perioperative area at your facility?
    a. Not at all familiar
    b. Somewhat familiar
    c. Moderately familiar
    d. Very familiar
10. How confident are you with your knowledge of the maximum allowable doses of local anesthetics (regional, neuraxial), specifically Bupivacaine, ropivacaine, and lidocaine with and without epinephrine?
    a. Not at all confident
    b. Somewhat confident
    c. Moderately confident
    d. Very confident
11. How familiar are you with the drugs to avoid with a patient diagnosed with LAST?
    a. Not at all familiar
    b. Somewhat familiar
    c. Moderately familiar
    d. Very familiar

Post-Implementation Survey Questions Ideas:

1. During the last two weeks how many cases have you been involved in that used local anesthetics during the case or in a peripheral nerve block?
    a. 0
    b. 1-5
    c. 6-10
    d. 11-15
    e. >15
2. During the last two weeks how many surgical cases that involved the use of local anesthetics did you identify as high risk for LAST?
    a. 0
    b. 1-5
    c. 6-10
    d. 11-15
    e. >15
3. How useful is the BICEPSS mnemonic: blood, intercostal, caudal, epidural, plexus, sciatic, subcutaneous in identifying patients receiving a block that would put them at higher risk for LAST
    a. Not at all helpful
    b. Somewhat helpful
    c. Moderately helpful
    d. Very helpful
4. In addition to being a lipid shuttle, the second main mechanism of action of lipid emulsion therapy (LET) includes:

   a. Alpha receptor agonist
   b. Beta receptor agonist
   c. Positive inotropic
   d. DNA synthesis inhibitor
5. How confident are you in your knowledge of the maximum allowable doses of local anesthetics, specifically Bupivacaine, ropivacaine, and lidocaine with and without epinephrine?
   a. Not at all confident
   b. Somewhat confident
   c. Moderately confident
   d. Very confident
6. How familiar are you with the drugs to avoid with a patient diagnosed with LAST?
   a. Not at all familiar
   b. Somewhat familiar
   c. Moderately familiar
   d. Very familiar
7. During the last two weeks did this Quick Reference Guide (QRG) improve your awareness of LAST?
   a. Yes
   b. No
   c. No change
8. During the last two weeks, while having access to the QRG, how confident were you in diagnosing and treating LAST?
   a. Not at all confident
   b. Somewhat confident
   c. Moderately confident
   d. Very confident
9. Do you support implementing a LAST QRG at your facility?
   a. Strongly oppose
   b. Oppose
   c. Neutral
   d. Support
   e. Strongly support
10. Do you have any recommendations to improve this QRG?

    _____