Assessing CRNA Perceptions of a Cognitive Aid Regarding Local Anesthetic Systemic Toxicity: A DNP Quality Improvement Project

Cordelia G. Rios, BSN, SRNA

Maura McAuliffe, PhD, CRNA, FAAN, Project Chair

Nurse Anesthesia Program

College of Nursing, East Carolina University

Submitted in partial fulfillment of the

requirements for the degree of Doctor of Nursing Practice

Finalized (11/30/25)

Notes from the Author

This project would not have been possible without the generous support from all CRNA participants. Thank you for your time, guidance, encouragement, and expertise throughout this process. Thank you to Dr. Maura McAuliffe, Project Chair for her many hours spent editing, cheering, and reassuring our team every step. Thank you to Dr. Nikki Roebuck for unwavering support, feedback, and hours upon hours of edits. This truly would not have been possible without you. Dr. Travis Chabo, thank you for coordinating the implementation of this DNP project and all you do for the anesthesia students. A special thanks to my husband, Nico Rios, for giving me the confidence to tackle big projects, such as this one. Lastly, thank you reader for taking the time to learn about this quality improvement project to ultimately improve anesthesia care.

Abstract

Local anesthetic systemic toxicity (LAST) is a rare but potentially catastrophic complication of local anesthetic administration in the perioperative and operative setting. The purpose of this Doctor of Nursing Practice (DNP) quality improvement project is to assess CRNA perceptions of the adequacy of a LAST Quality Reference Guide designed to assist in identifying high-risk patients to quickly diagnose and appropriately treat LAST should it occur. The setting of this QI project was an outpatient surgery center located in the southeastern United States. Five of seven CRNAs participated in this quality improvement project over a two-week implementation period. Key components of the project were the creation, implementation, and evaluation of CRNAs' perceptions of the LAST Quality Reference Guide (QRG). The guide summarizes current evidence-based guidelines for LAST management and was introduced through a narrated PowerPoint Presentation to participants via email. A pre-implementation survey and a post-implementation survey were administered to participants. The results of this quality improvement project were positive. All participants who responded to the surveys agreed that the QRG and project implementation increased their awareness of LAST. No recommendations were made to improve the QRG. A major limitation of this project was the small sample size. Subsequent iterations of this quality improvement project should include a larger sample size for a longer implementation period to obtain data that may be generalizable in a larger hospital setting.

Keywords: anesthesia, local anesthetic systemic toxicity, educational resource, CRNA

Table of Contents

Section I. Introduction to Local Anesthetic Systemic Toxicity

Background

Local Anesthetic Systemic Toxicity (LAST) is a rare yet often detrimental complication of local anesthetic administration. Anesthesia providers promote high-quality pain management in surgical patients through multimodal pain management techniques. Local anesthetics used in regional blocks for pain management have increased in popularity due to the quality of pain management delivered, decreased opioid use in the post-operative setting, and increased patient satisfaction (On'Gele et al., 2022). Multimodal approaches to pain management have produced many positive outcomes with a decline in opioid administration, making them an attractive technique for many anesthesia providers. However, with increased use of local anesthetics, the risk of LAST also increased.

The occurrence of LAST has been documented for over a century. In 1887, systemic toxicity related to the administration of cocaine for local anesthesia was first documented (Drasner, 2010). Based on the knowledge that cocaine is a benzoic acid ester, procaine was patented in 1904 in an effort to develop a less toxic local anesthetic. Two decades later, systemic toxicity proved to be an issue even with procaine. The Committee for the Study of Toxic Effects of Local Anesthetics from the American Medical Association, led by Dr. Emil Mayer, published a review of LAST in 1924. The committee's brief report identified 42 known fatalities from the toxic effects of local anesthetics (Mayer, 1923). Of the 42, 18 were attributed to cocaine toxicity, and three to procaine toxicity. The committee published a full article in 1924 noting 43 documented deaths and their recommendations for the prevention of LAST, including the addition of epinephrine to local anesthetics, which will be discussed further as a current modality of LAST prevention used today (Mayer, 1924).

Although the true prevalence of LAST is not known, the current best estimate is 0.03% or 0.27 per 1,000 peripheral nerve blocks, with 4.3% resulting in death (El-Boghdadly et al., 2018; Gitman & Barrington, 2018). Underreporting is a standard explanation for the variance in case rates. Waldinger et al. (2020) agree that the incidence of LAST is presumably higher related to misdiagnosis. These statistics demonstrate that LAST is a relatively rare complication; however, when it does occur, it is a medical emergency. To limit patient morbidity and mortality, anesthesia providers must know how to quickly diagnose and treat LAST if symptoms should arise to mitigate the profound systemic consequences of local anesthetics.

Local anesthetics are weak bases with a common lipophilic aromatic ring connected through either a carboxylic ester or amide to a hydrophilic tertiary amine (Arumugam et al., 2020). The amino ester and amino amide link determine the classification of the local anesthetics and how the anesthetic is metabolized. Although local anesthetics have similar structures, they differ in their distinct pKa, lipid solubility, and protein binding, which alters their clinical effect. Local anesthetic mechanism of action is through reversible binding to voltage-gated sodium channels along nerve axons to inhibit the transduction of a nerve impulse (Suzuki et al., 2019). Local anesthetics bind to voltage-gated sodium channels during the activated and inactivated state, but not during the channels' resting state. Due to the high affinity for local anesthetics during the activated and inactivated states, blocks that include local anesthetics are use-dependent blocks. The location of the block impacts the rate of local anesthetic systemic absorption. Risk for systemic absorption is ranked by location from greatest to least as follows: intravenous, intercostal, caudal, epidural, brachial plexus, sciatic, and subcutaneous administration. Equal doses of local anesthetics can result in increased plasma concentrations

depending on the location of the block. Understanding the nuances of different blocks is essential for anesthesia providers to avoid the risk of LAST.

The partnering organization prides itself on delivering high-quality healthcare to rural communities in southeastern United States. As part of this mission, anesthesia professionals at this organization strive to remain current in all areas of practice, including the administration of anesthetics, through continuing education. In conjunction with the American Association of Nurse Anesthesiology (AANA, 2019) Standards for Nurse Anesthesia Practice, nurse anesthetists at the project site maintain their commitment to serve their community through quality improvement projects that contribute to safe and effective anesthesia care. With emphasis on patient safety and using best practices, this DNP project will focus on creating a quick reference guide (QRG) for CRNA use when caring for patients receiving local anesthetics.

Organizational Needs Statement

The project site does not currently have a published quality reference guide or LAST checklist for anesthesia providers to use if LAST were to occur. To ensure the hospital meets its patient safety mission and to comply with the Standards for Nurse Anesthesia Practice set forth by the AANA (2019), an easy-to-access resource to manage events such as LAST should be readily available. A QRG would be helpful in maintaining adherence to evidence-based practices regarding LAST management and could aid anesthesia providers in administering appropriate and timely treatment. Regional anesthesia used as a multimodal approach to pain management is increasing due to improved patient outcomes, including decreased postoperative opioid use (On'Gele et al., 2022).

Problem Statement

Local anesthetic systemic toxicity (LAST) is a serious, life-threatening complication resulting in central nervous system excitation, possible cardiovascular collapse, and death. Although the true incidence of LAST has not been established, in part due to under-reporting, the current best estimate is 0.03% or 0.27 per 1,000 peripheral nerve blocks, with 4.3% of affected patients resulting in death (El-Boghdadly et al., 2018; Gitman & Barrington, 2018). In addition to poor patient outcomes, LAST is associated with increased hospital costs, increased length of stay, and decreased patient satisfaction. Providing a QRG can ensure the provision of life-saving elements of care should this event occur. Currently, the project site does not have a LAST treatment checklist in place.

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 Quality 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 quality improvement projects aimed at improving this rare but potentially catastrophic preoperative event at this facility.

Section II. Evidence

Description of Search Strategies

The purpose of this literature review was to establish evidence for the usefulness of a LAST reference tool to help guide anesthesia providers in the identification and management of LAST. Using the PICOT framework, a question was synthesized by naming the problem, intervention, comparison, outcome, and timeframe that would be most useful to this quality improvement project. The following PICOT question was used to guide the literature search process: In Certified Registered Nurse Anesthetists (CRNAs) administering local anesthetics, does a quick reference tool increase their awareness, knowledge, and confidence when confronted with LAST? Appendix A outlines the four primary concepts used to guide this PICOT question in a table format. Those four concepts were "CRNA," "Local Anesthetic Systemic Toxicity," "Reference tool," and "confidence." Inclusion criteria for populated articles through this search strategy were if the article is pertinent to the project, CRNA population, complication of LAST, use of local anesthetics, and positive correlation to PICOT question. Exclusion criteria were defined as articles not pertinent to the project, neither CRNA nor anesthesia provider population, a complication of LAST, or were outside of the perioperative setting. Inclusion criteria included peer-reviewed, published within the past 5 years, and written in English.

The literature search relied on the databases PubMed and Cumulative Index to Nursing and Allied Health Literature (CINAHL) and the search engine Google Scholar. Medical Subject Headings, known as MeSH terms, used in the PubMed database included "nurse anesthetists," "anesthetics, local," "anesthesia conduction," "reference books," "handbooks," "resource guide," and "self-concept." MeSH terms were combined with Boolean operators such as AND and OR to

combine the search strategies. The simple search strategy used in PubMed is as follows: (“anesthetics, local” OR “anesthesia, local”) AND (“anesthetists”). Search results were limited in the PubMed database to articles published in the past 5-year period (2019-2024), peer-reviewed articles, and published in English. This search yielded two results. The title and abstract were reviewed for both, and one was selected for full-text review. By adjusting search limitations to articles published in the past 5-year period and in English, 33 articles populated. The title and abstract were reviewed for the 33 articles. Four of those were kept for a full-text review. All four articles were kept after a full text review. The search date and complete MeSH search strategy were compiled into a search log found in Appendix B.

The subject headings used in the CINAHL database were: “certified registered nurse anesthetists,” “anesthetics, local,” “anesthetics, intravenous,” “anesthetics,” “anesthetics, dissociative,” “reference tools,” “confidence,” and “knowledge.” Subject headings were combined with Boolean operators such as AND and OR to combine the search strategies. The search strategy used in CINAHL included: ((MH "Certified Registered Nurse Anesthetists") AND (MH "Anesthetics, Local") OR (MH "Anesthetics, Intravenous") OR (MH "Anesthetics") OR (MH "Anesthetics, Dissociative"). Search limitations applied in the CINAHL database were articles published in the past 5-year period (2019-2024), peer-reviewed articles, and written in English. This resulted in 60 articles, of which one was pertinent for inclusion. This search resulted in 60 articles that were reviewed by title and abstract for inclusion criteria. After title and abstract review, one was kept for full-text review and retained to inform the project tool.

Key terms used in Google Scholar included “CRNA,” “nurse anesthetist,” “nurse anesthesia,” “certified registered nurse anesthetist,” “LAST,” “local anesthetics,” “local anesthesia,” “local toxicity,” “reference guide,” “reference tool,” “self-confidence,”

"confidence," and "knowledge." With the sole limitation of articles published in the previous 5 years (2019-2024), Google Scholar yielded 113 pages of results. Of the 113 pages, 20 pages were reviewed by article title, and 10 were kept for additional abstract review. Five of the 10 were selected for a full-text review. One was kept for full-text review and retained to inform the project tool. Additional articles were discovered by reviewing the references of those kept for full-text review, along with professional organization websites, including the American Society of Regional Anesthesia and Pain Medicine (ASRA). After reviewing the reference lists and professional organizations, two were kept. See Appendix A for a clear outline of concepts and Appendix B for specific search strategies and dates.

By evaluating articles based on specified inclusion criteria, eight articles were selected to inform the project. Articles were classified by their level of evidence based on Melnyk & Fineout-Overholt (2019) guidelines. The highest level of evidence being Level I and lowest level of evidence being Level II. Six of eight reviewed articles were classified as evidence Level VI, meaning they were a descriptive or qualitative study, case study, evidence-based project, or an implementation and quality improvement project. The remaining two articles were classified as evidence Level VII based on established guidelines. Evidence at level VII indicates expert opinion from individuals or groups. See Appendix C to review a literature matrix with details regarding reviewed articles.

Selected Literature Synthesis

Signs and Symptoms of LAST

Early identification of LAST is a key predictor of patient outcomes, and anesthesia providers must vigilantly assess for LAST signs and symptoms to initiate timely interventions (Ferguson et al., 2019; Macfarlane et al., 2021). Central nervous system (CNS) and

cardiovascular (CV) symptoms are two of the most common manifestations of LAST noted in the reviewed evidence (Arumugam et al., 2020; Gitman & Barrington, 2018; Suzuki et al., 2019). Excitatory central nervous system features occur due to inhibition of regulatory cortical pathways (Arumugam et al., 2020). As plasma concentrations of intravascular local anesthetics continue to rise, excitatory clinical features transition to CNS depression, resulting in cardiac depression and respiratory arrest. Prodromal CNS symptoms include visual and auditory disruptions, periorbital numbness, dizziness, or lightheadedness. After conducting their in-depth literature review, Gitman & Barrington (2018) concluded that seizures were the most common manifestation of LAST in 61% of reported cases. Severe cardiovascular symptoms, including dysrhythmias and cardiac arrest as a result of conduction disturbances, can also occur, although CNS symptoms of LAST are more extensively reported.

Prevention of LAST

It is more beneficial to prevent LAST than to manage its treatment. Knowledge of human anatomy, toxic doses, pharmacokinetics, and pharmacodynamics of local anesthetics is fundamental to its prevention (Suzuki et al., 2019). Patient risk factors, such as age, pregnancy status, hepatic disease, renal impairment, and cardiac disease, must be factored into the plan of care by the anesthesia provider to better mitigate the chance of LAST (El-Boghdadly et al., 2018; Macfarlane et al., 2021). The addition of low-dose epinephrine to local anesthetics is often used as an early sign of intravascular injection (Arumugam et al., 2020). Ultrasound is considered an essential tool demonstrated to decrease LAST in regional anesthesia by allowing direct visualization of anatomy, vasculature, needle tip, and spread of local anesthetic upon injection (Arumugam et al., 2020; Macfarlane et al., 2021). Although ultrasound-guided administration is associated with a decreased risk of LAST, the symptoms of toxicity tend to be delayed from the

time of administration (Macfarlane et al., 2021). Slower onset of LAST symptoms may become more common as use of ultrasound increases. Along with ultrasound-guided administration of local anesthetics, frequent aspiration upon injection and incremental injection are recommended as prevention measures to avoid direct injection into vasculature (Gitman & Barrington, 2018; Macfarlane et al., 2021). The literature reviewed clearly states that mitigating techniques should be used in combination as any single measure is likely insufficient to prevent LAST.

LAST Management and Lipid Emulsion Therapy

The American Society of Regional Anesthesia and Pain Medicine (ASRA) recently published new guidelines for the management of LAST (Neal et al., 2021). The guidelines include a comprehensive checklist for provider use should LAST occur. As part of initial action, providers must consider early administration of lipid emulsion therapy (Ferguson et al., 2019; Macfarlane et al., 2021, Tkach et al., 2023). Tkach et al. (2023) identified through survey analysis, that CRNAs correctly recognized early lipid emulsion therapy as a key component of LAST management. Use of intravenous lipids is documented as a major advancement in the treatment of LAST and should be administered at the first clinical sign of LAST (Arumugam et al., 2020). Intravenous lipid emulsion therapy provides a “lipid sink” for the local anesthetic to bind (El-Boghdadly et al., 2018; Ferguson et al., 2019). Local anesthetic molecules favor binding to the lipid over the sodium channel, which decreases the amount of local anesthetic available to produce symptoms of toxicity. The local anesthetic molecules follow their typical pathway of metabolism and are later excreted through the kidneys (Ferguson et al., 2019). Lipid emulsion therapy (LET) has dual action. Positive inotropic effects on the heart are seen clinically with LET (El-Boghdadly et al., 2018).

Anesthesia providers should also be aware of recommended deviations from typical Advanced Cardiac Life Support (ACLS) protocols when LAST is suspected. The dose of epinephrine should be altered to less than one mcg/kg (Arumugam et al., 2020; El-Boghdadly et al., 2018; Ferguson et al., 2019). The administration of lidocaine, as well as calcium channel blockers and beta-blockers, during cardiopulmonary resuscitation, is contraindicated in the treatment of LAST (Arumugam et al., 2020; Ferguson et al., 2019.) Airway management continues to remain a top priority, along with vasopressor support for hemodynamic stabilization (Macfarlane et al., 2021).

Synthesis Summary

LAST will always be a risk of local anesthetic administration (El-Boghdadly et al., 2018; Gitman & Barrington, 2018; Macfarlane et al., 2021). However, each article reviewed postulated that increased awareness and ongoing provider education about implementing quick resuscitation protocols will mitigate patient harm, and keep LAST as a rare occurrence. Ultrasound-guided regional anesthesia is a key tool used during the administration of local anesthetics to decrease the incidence of LAST (Macfarlane et al., 2021). While the literature is clear that CRNAs are aware of lipid emulsion therapy in the management of LAST, there is still a lack of timely and appropriate use of this therapy (Arumugam et al., 2020; Ferguson et al., 2019). Cognitive aids and emergency manuals have been demonstrated to improve performance and increase patient safety in high stress situations (Neal et al., 2021; Tkach et al., 2023). The checklist put forth by ASRA is an excellent tool to help providers identify high-risk patients and then quickly diagnose and appropriately treat LAST should it occur (Neal et al., 2021).

Project Framework

The methodology which this quality improvement project was designed from is the plan-do-study-act (PDSA) cycle developed by the Institute for Health Care Improvement (IHI). The PDSA cycle is a four-step process that is used for recording a change implementation (IHI, 2017). This project focused on one PDSA cycle to assess the implemented change idea, rather than multiple changes needing to be tested. Step 1 of the PDSA is to *plan*. This involves synthesizing a question, predicting what might happen, and assessing ways to collect data. *Do* in the PDSA cycle is to carry out the implementation strategy or test and record the data. The third step, *study,* is to compare the data from Step 2 to the predictions made in Step 1. Step 4, *act,* is to decide what action to take based on the results. The PDSA cycle may then start over at Step 1.

The PICOT question was a major component of the planning phase. Within the plan, an idea of how to collect data was established and what tool would be implemented at the project site. The LAST QRG was developed in this phase. This plan was based on the literature synthesis and expert opinion from the project chair. The second step, *do,* in the PDSA cycle is implementing the designed tool, carrying out specified procedures, collecting data through surveys, and the beginning of data analysis. This was completed by implementing the LAST QRG and providing education to anesthesia providers at the project site. The third step, *study,* in the PDSA cycle is to study the data collected from the project site. Lastly, the fourth step, *act*, in the PDSA cycle is either to make changes or recommendations based on the findings evaluated in the study phase.

Ethical Considerations and Protection of Human Subjects

Preparation for a formal review process to ensure complete ethical transparency was completed through the Collaborative Institutional Training Initiative (CITI) Program

(https://about.citiprogram.org/). All persons conducting this quality improvement project completed the CITI training modules. No risk or harm to participants in this quality improvement project were identified outside of the usual stressors of an anesthesia provider's typical workday. Participation from the anesthesia providers involved was voluntary and any participant data kept confidential. No patients were direct participants of this project. Direct patient care or interactions were not involved. No patient data was utilized in this quality improvement project.

Formal approval was granted for this quality improvement project through East Carolina University College of Nursing and the Health System Review process. This project was deemed exempt from a full IRB approval process. Project site approval was also obtained, and signatures were provided by local project site personnel for approval of data collection. A copy of these processes can be found in Appendix D.

Section III. Project Design

Project Setting

The setting of this quality improvement project is an outpatient surgery center located in the southeastern United States. This surgical center, licensed and accredited by The Joint Commission, consists of 10 operating rooms and provides a wide range of outpatient surgical procedures. Orthopedic procedures requiring local anesthetics for regional nerve blocks, such as knee and shoulder arthroplasty, are routinely performed at the surgical center. The routine administration of local anesthetics made this an excellent environment for the implementation of a LAST QRG. Patients served at the surgery center are likely to receive nerve blocks using local anesthetics to help decrease the number of opioids used during the anesthetic and assist in quick recovery in the post-anesthesia care unit (PACU). The surgery center utilizes CRNAs in patient care which facilitates assessment of CRNAs perceptions in the surgical setting about the QRG. The fast pace of the surgical center and production pressure may act as a barrier as CRNAs may not prioritize their review of the LAST QRG.

Project Population

This quality improvement project focuses on the population of CRNAs working at the participating facility as full-time employees. A CRNA is a certified registered nurse who gained experience in the intensive care unit setting and returned to school to further their education through a Master's (MSN) or Doctoral (DNP) Program. CRNAs are Advanced Practice Nurses who have specialized in anesthesia care. The anesthesia care model in place at the project site is a collaboration between CRNAs alongside anesthesiologists who oversee multiple operating rooms. A single CRNA is assigned to one operating room while a single anesthesiologist may be overseeing multiple. Project implementation was facilitated through established relationships

between the university and the surgical center. Previous involvement in student lead quality improvement projects also provided familiarity to the CRNAs involved in the implementation process. Another facilitator to project involvement was the desire to stay up-to-date on best practice in the clinical setting.

Project Team

The project team included the author, a Student Registered Nurse Anesthetist (SRNA), as the project lead, alongside three additional SRNAs, and several university faculty members. The *project chair*, a university faculty member, CRNA, and founder of the anesthesia program, oversaw project implementation, advised on scholarly writing, and provided critical guidance throughout the project's entirety. The current program director served as the *clinical contact* and was instrumental in recruiting CRNAs at the project site. The rest of the team includes the *course director*, who provided step-by-step guidance in the quality improvement implementation process and detailed feedback regarding course writing, and the *site contact person*, a clinical coordinator, who signed the letter of acknowledgement that data will be collected at project site. While the initial work of the project was performed as a team, the implementation and analysis of data collected at the project site was completed independently the author.

Methods and Measurement

Key components of this quality improvement project were to create, implement, and evaluate the CRNAs' perceptions of the LAST QRG. The QRG outlined the most recent evidence-based practice guidelines about management of LAST (Appendix E). Information further explaining this quality improvement project and the QRG was provided to the CRNAs through a narrated PowerPoint Presentation. The QRG and PowerPoint presentation were delivered to participants via email (Appendix F). Prior to this instructional material, a pre-survey

questionnaire was administered to participants. After the 2-week implementation of the project, a follow-up post-implementation survey questionnaire was administered. The pre-and post-implementation questionnaires may be found in Appendix G. Perceptions of the QRG were assessed through analysis of the pre- and post- implementation surveys. Knowledge gained through this quality improvement project may then be aimed at improving this rare but potentially fatal perioperative event.

A single PDSA cycle was completed through this DNP quality improvement project. The *planning* of this project started with an in-depth literature search and subsequent review of the literature. The project lead conducted a literature review based on an established PICOT question regarding the most recent evidence-based practices in the prevention, identification, and treatment of LAST. Literature was further reviewed for evidence to suggest that a standardized tool benefits anesthesia providers in emergent situations. The literature reviewed was then compiled into a Literature Matrix (Appendix C) to provide organization of the evidence. Multiple meetings were held among the project chair and collaborating SRNA students to review scholarly references and refine the purpose and project statements. The SRNA students collaborated to produce the QRG, Qualtrics Survey questions, and narrated PowerPoint presentation during the planning phase. Each item was reviewed prior to implementation by the project chair through multiple project meetings and draft revisions.

The second, *do,* phase of the PDSA cycle required participant involvement via communications between the clinical contact and the site contact person. A brief overview of the quality improvement project was presented to the participating anesthesia providers by the clinical contact. Names and contact information of the participating individuals were relayed to the project lead via the clinical contact. Selected participants from the project site were emailed a

confidential link to the pre-implementation survey questionnaire via Qualtrics (Appendix G). To assess current familiarity and confidence in implementing evidence-based practices about LAST, the Qualtrics Survey used questions on a Likert scale. The post-implementation survey aligned with the pre-implementation survey and assessed the participants' perceptions of the effectiveness of the QRG.

Following completion of the pre-implementation survey questionnaire, a narrated PowerPoint presentation was delivered to participants via email to provide further information about LAST and details pertaining to implementation of the LAST QRG. The narrated PowerPoint presentation was created in collaboration between the SRNA students and drafts were revised following meetings with the project chair. The project participants at the designated project site were able to download the PowerPoint presentation along with the QRG to use at their discretion throughout the two-week implementation period. To verify a hard copy was available for use, a laminated copy of the one-page QRG (Appendix E) was hand-delivered by the project lead to the project site. After two weeks of implementing the provided resource, a second confidential link to the post-implementation survey was delivered via email to the participating anesthesia providers. Results from both the pre- and post-implementation surveys remained confidential and were obtained electronically via Qualtrics.

The Qualtrics survey results were analyzed in the third phase of the PDSA cycle. Data collected from the pre-and post-implementation survey was analyzed in Excel. All data collected and analyzed remained anonymous. Pre- and post-implementation survey questionnaires were compared to assess the CRNAs' perceptions of the QRG, and a visual representation of the data was created in Excel. The fourth phase, *act,* of the PDSA cycle, involved the dissemination of the acquired knowledge from this DNP Quality Improvement project to the public. The

discovered information was compiled into a poster presentation and presented to fulfill DNP course requirements. The project implementation, data analysis, and poster presentation were completed independently by the project lead.

Section IV. Results and Findings

Results

This Doctor of Nursing Practice (DNP) quality improvement project aimed to assess CRNA perceptions of the adequacy of a LAST Quick Reference Guide (Appendix E) designed to assist in identifying high-risk patients to quickly diagnose and manage LAST in an emergency. The data exploring CRNA perceptions were collected via two pre-and post- implementation surveys (Appendix G), which included an easy to access link to the Qualtrics surveys. Surveys were sent via email to seven CRNAs at the participating surgical center. A two-week implementation period was set, and survey responses were collected over the specified 14-day implementation period. Easy to click links were embedded within the emails to provide ease in survey accessibility. The emails are found in Appendix F. Surveys were produced and distributed via Qualtrics and analyzed via Excel software. Five CRNAs completed the pre-implementation survey. Three CRNAs completed the post-implementation survey.

Data Presentation

The pre-implementation survey included questions exploring participant years of practice and familiarity with LAST management. Regarding years of experience as a CRNA, five of five participants selected *greater than 10.* Pertaining to frequency of local anesthetic use at project site, one of five participants selected *weekly,* and four of five selected *daily*. One of five participants selected *somewhat familiar*, two of five responded *moderately familiar*, and two of five selected *very familiar* with LAST. Regarding pre-implementation confidence level of LAST management, three of five participants selected *moderately confident*, and two selected *somewhat confident*. Regarding the CRNAs confidence in dosing lipid emulsion therapy (LET) in the treatment of LAST, one of five participants responded *moderately confident*, three of five

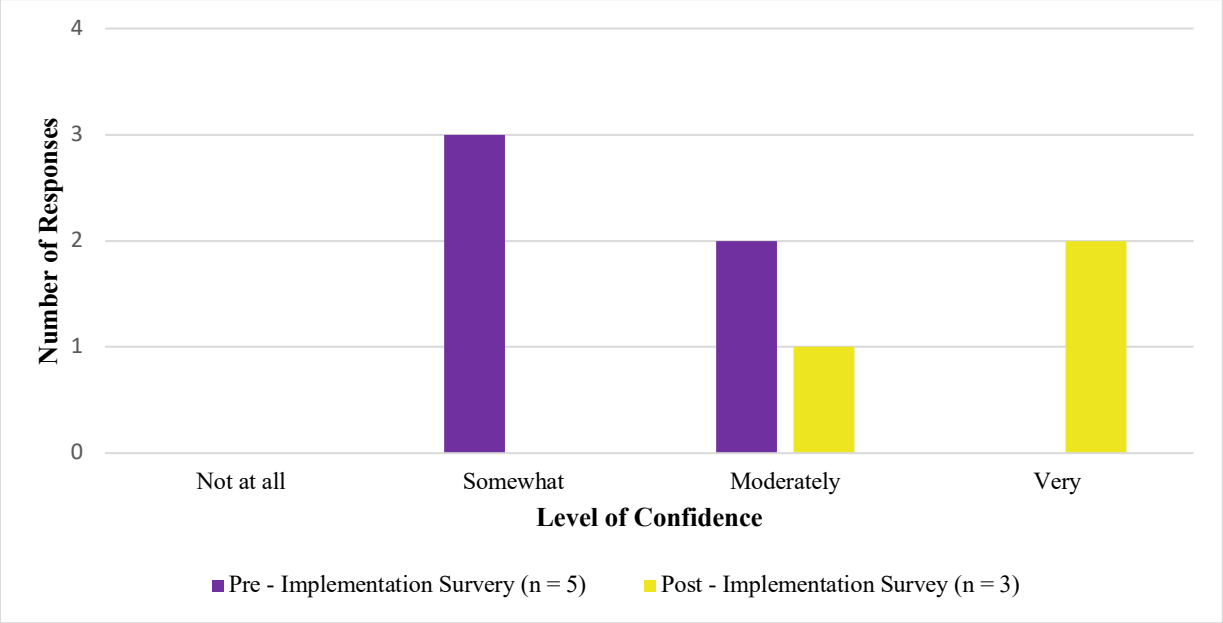
participants selected *somewhat confident*, and one selected *very confident*. Assessing the CRNAs knowledge of the location of lipid emulsion therapy (LET) storage at their facility of practice, one selected *somewhat familiar*, two selected *moderately familiar*, and two selected *very familiar*.

The post-implementation survey explored how often local anesthetics were administered during the two-week implementation period and how many surgical cases were at risk of LAST. Two questions in the post-implementation survey aimed to assess if the implemented QRG improved CRNA awareness of LAST and asked for suggestions to improve the QRG. Regarding frequency of local anesthetic use in peripheral nerve blocks throughout the implementation period, one of three participants responded *one to five,* and two selected *greater than 15*. Concerning the number of surgical cases at high risk of LAST, one selected *zero*, one selected *one to five*, and one selected *six to ten*. When asked if the QRG improved participants awareness of LAST over the two-week implementation period, three responded *yes*. When asked if they support the implementation of the LAST QRG at their facility, one responded *neutral*, one responded *support*, and one *strongly support*. Recommendations to improve the LAST QRG were not provided from any participant.

A few questions on the pre- and post- implementation survey were written the same to allow for comparison pre- and post- implementation. Questions five and nineteen on the pre- and post- implementation surveys respectively, assessed the participants' confidence in the diagnosis and treatment of LAST. Pre-implementation, three of five participants responded *somewhat confident*, and two of five responded *moderately confident*. Post-implementation, one of three respond *somewhat confident* and two of three respond *very confident* (see Figure 1 below).

Figure 1

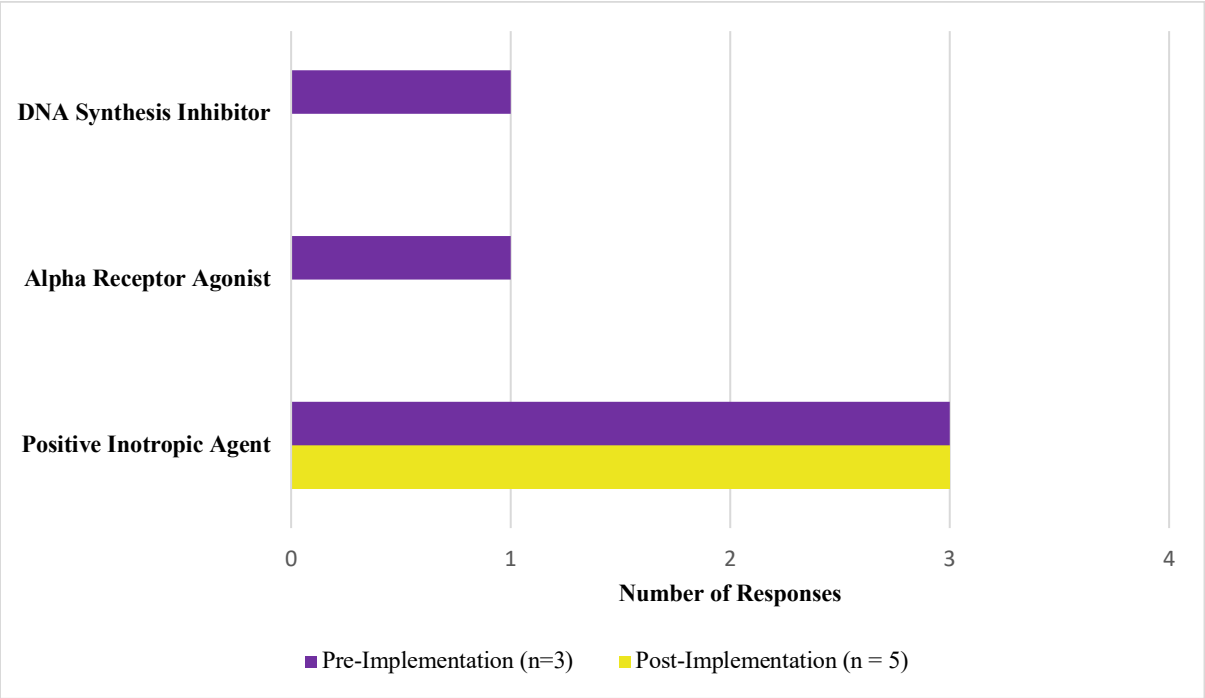
How confident are you in the diagnosis and treatment of LAST?



When assessing the participants' pre-implementation familiarity of the BICEPPS mnemonic, three of five participants responded *not familiar at all*, one responded *moderately familiar*, and one responded *very familiar*. Post-implementation, three participants respond *very useful* and one *somewhat useful*. When assessing the participants' knowledge of the second mechanism of action of lipid emulsion therapy (LET), one responded *DNA synthesis inhibitor*, one responded *alpha receptor agonist*, and three responded *positive inotropic agent*. Post-implementation, all three participants respond correctly by answering *positive inotropic agent* (see Figure 2 below).

Figure 2

In addition to being a lipid shuttle, the main mechanism of action of lipid emulsion therapy (LET) includes:



Questions on the pre- and post- implementation surveys explored the participants' confidence in their knowledge of the maximum allowable doses of local anesthetics. Pre-implementation, one of five participants responded *moderately confident*, and four responded *very confident*. Post-implementation, one participant responded *somewhat confident*, and two responded *very confident*. When assessing the participants' familiarity with the drugs to avoid when a patient is diagnosed with LAST, pre-implementation, four of five responded *somewhat familiar*, and one responded *moderately familiar*. Post-implementation, two of three participants respond *somewhat familiar*, and one *very familiar*.

Analysis

All participants of this study had been CRNAs for more than 10 years. It is reasonable to assume from this data these CRNAs have had great experience with the administration of local

anesthetics and knew about the risk of LAST with the administration of local anesthetics. Four of five participants reported using local anesthetics in their daily practice. It can be inferred that over the combined 40+ years of practice amongst the four CRNAs who use local anesthetics in their daily practice, the avoidance of LAST has been a priority and all five reported some familiarity with LAST in the pre-implementation survey. In other words, none of the CRNAs in this study were learning about LAST for the first time. While LAST was not a new concept, none of the CRNAs reported being *very confident* in the diagnosis and treatment of LAST in the pre-implementation survey. Post-implementation, two responded that they were *very confident* in the diagnosis and treatment of LAST. This shows an improvement in their reported confidence level. While there were two less respondents on the post-survey, there remains an overall increased confidence level in the diagnosis and treatment of LAST. The data therefore indicates implementing the QRG and PowerPoint Presentation may have had a positive impact in improving the participating CRNAs' confidence in the diagnosis and treatment of LAST.

All participants agreed that the QRG and project implementation increased their awareness of LAST. The data analysis demonstrated that none of the CRNAs would be opposed to the permanent implementation of the LAST QRG at their facility. Further, none of the CRNAs offered suggestions on how the LAST QRG could be improved to make the QRG more suitable for their practice. It can be inferred that the participating CRNAs are content with the LAST QRG in its current form without any alterations. When assessing the CRNA's current knowledge of the second main mechanism of action of lipid emulsion therapy (LET) in the treatment of LAST, three of the five participants answered correctly, and two answered incorrectly on the pre-implementation survey. On the post-implementation survey, all participants responded correctly. It is unknown if the two participants who responded incorrectly on the pre-implementation

survey were also the two participants who did not answer the post-implementation survey questions. Since this is unknowable, it is unclear if the LAST QRG improved the participants' awareness of the second main mechanism of action of LET.

Five of the seven participants answered the pre-implementation survey, and three of those five answered the post-implementation survey. It is difficult to explain why two participants who answered the pre-implementation survey did not answer the post-implementation survey. The project lead can speculate as to possible reasons but does not have supporting data. Potential reasons participants may not have answered the postimplementation-survey include illness, scheduled vacation time, or busy scheduling. It may have been beneficial to provide a second reminder email, instead of one reminder email during the 14-day implementation period. Alternatively, a longer implementation period could have allowed more time for all participants to answer post-survey questions.

Section V. Implications

Financial and Nonfinancial Analysis

The purpose of this quality improvement project was to assess CRNA perceptions of a Quick Reference Guide aimed at improving the treatment and management of LAST. There was no direct or indirect monetary benefit from the implementation of this project. This quality improvement project was completed in partial fulfillment of a Doctor of Nursing Practice degree and no monetary benefit was awarded to any participants or project team members. The project site was not charged for any costs associated with project implementation.

The cost of this quality improvement project implementation remains far less than the potential treatment for an adverse event such as LAST. A single adverse event can lead to unplanned hospital admission, increased length of stay, and further medical treatment ranging on average from $4,000 to $29,500 (Merkow et al., 2020). This estimate does not include the cost of litigation or any settlement costs. The primary costs to subsequent implementations of this project are seven pieces of laminated printer paper and approximately 15 minutes of employee time for project implementation. The cost of printing in color and laminating seven pieces of printer paper would be around $8 (US). This cost was covered in the project lead's graduate tuition. All seven laminated QRG's are available for use if this quality improvement project should be re-implemented at the project site. Therefore, there would be no extra cost to create new laminated copies of the QRG to replicate this project.

The greatest resource used to implement this quality improvement project was time. A single employees time would be needed to carry out the project, design and print a LAST QRG, create an educational PowerPoint presentation, and disseminate results. The cost for a full-time non-clinical employee to implement this project in one week at an hourly rate of $30/hr. would

be $1,200. If the implementation of this project theoretically prevented a single patient from the adverse event of LAST, the implementation site may save between $2,800 - $28,300 based on the average hospital cost of an adverse event (Merkow et al., 2020). The cost and potential benefit of having a LAST QRG available outweighs the possible cost the partnering facility may incur due to an adverse event of LAST. Little opposition would be expected to the reimplementation of this project as it does not interfere or alter the current workflow of CRNAs at the implementation site. The subsequent implementations of this QI project would likely produce a positive return on investment for the project site.

Qualtrics survey software, Microsoft Excel, and Microsoft PowerPoint were three applications utilized by the project lead to carry out survey creation, implementation, and data analysis of this QI project. All three applications were provided through ECU College of Nursing and paid for in the project lead's graduate tuition. All three applications require a subscription for use. Microsoft Excel and PowerPoint are typical applications used at the project site and widely used throughout the healthcare system. It would be likely the project site already has these applications available at no additional cost. Although a subscription to Qualtrics is required for use, an alternative survey application could be used at no additional cost to accomplish the same task. Email was the primary method of communication used to distribute information to participants of this project. While email is a free tool, the participants did require access to a computer or smart phone with internet to access those emails. Numerous computers are available at the project site for use in daily practice and all participants had a smart phone for their personal use. No extra cost can be attributed to communication modalities outside of the time it took to compose and send emails.

Implications of Project

The American Association of Nurse Anesthesiology (AANA, 2019) regards participation in quality improvement as one of the 12 Standards of Care every CRNA should follow. By actively participating in this quality improvement project, the CRNAs at the project site maintain their commitment to improving nurse anesthesia, their personal practice, and patient safety at their workplace. The data from this quality improvement project did demonstrate a positive increase in CRNA awareness of LAST. Further, the data mirrored the participants increase in awareness with an increase in confidence level when dealing with a patient emergency regarding LAST. To mitigate patient harm and maintain LAST as a rare event, increased awareness and continued CRNA education concerning timely implementation of resuscitation protocols is essential (El-Boghdadly et al., 2018; Gitman & Barrington, 2018; Macfarlane et al., 2021). All participants of this project agreed their awareness of LAST and confidence in handling this emergency have improved through the PowerPoint presentation and implementation of the LAST QRG. This data directly correlates to standard nine, Provision of Quality Care, set forth by the AANA.

By increasing awareness and CRNA confidence when dealing with a life-threatening emergency, overall patient safety is improved. This cost-effective QI project did both of those tasks with minimal disturbances to the participating CRNAs' daily routine. By implementing a readily available QRG and having increased awareness of LAST, a CRNA can recognize the signs and symptoms in seconds and quickly implement appropriate, evidence-based care in a timely manner to improve patient outcomes. Improved patient outcomes lead to an overall cost-saving seen by both the patient and the healthcare facility. As the benefits of a simple QRG are

clear, the data demonstrated that CRNA participants in this quality improvement project were not opposed to the permanent implementation of the LAST QRG at their healthcare facility.

Sustainability

This quality improvement project highlights patient safety and best evidence-based practice which are attributes all CRNAs in any patient-care setting work diligently to practice. The project site can feasibly expand this quality improvement project as costs of implementation were minimal, the benefits of LAST prevention and timely treatment outweigh the cost of patient harm, and there was no employee opposition to project implementation. Daily workflow of participating CRNAs was not impacted in the implementation of this project. The implementation of the LAST QRG can be seamlessly integrated as a tool in case of emergency without disturbance to daily routine. The data collected demonstrated an overall positive perception of the LAST QRG by the small sample size studied in the project. Subsequent implementation using a larger sample size would provide a larger data pool to assess the already created LAST QRG. Potential feedback through conducting a second round of the plan-do-study-act (PDSA) cycle could further refine the current LAST QRG to be used on a broader scale within a larger hospital setting.

Barriers to sustainability of this project may include staff turnover and education of incoming staff on the location of the LAST QRG. A designated person, potentially a charge CRNA or Quality Improvement (QI) director, would need to educate incoming staff about the LAST QRG and provide the PowerPoint presentation to new personnel. As there is already a large amount of information for a new hire to learn, a LAST QRG may not take priority. A potential solution to this barrier may be semi-annual or quarterly re-education through email communication. A second barrier could be the potential lack of ownership of the LAST QRG. In

order for the quality improvement project to remain active, a designated person would need to lead the implementation of the project to ensure the QRG presence and continued education to staff. This person may also act as a liaison to answer any questions on the use of the QRG and safeguard the project. Finding a qualified person to agree to this role may pose a barrier to the sustainability of this project.

Dissemination Plan

A poster and oral presentation to the ECU Nurse Anesthesia Class of 2026 was presented by the project lead at ECU College of Nursing. All participants of this QI project were invited to attend the poster presentation, along with family members, ECU Nurse Anesthesia and College of Nursing faculty members. The poster presentation included the project purpose, design, results, analysis, and implications of the quality improvement project. Guests were able to view this poster presentation via Webex live stream and in-person. The final version of this DNP paper was published on The Scholarship, a digital archive for ECU scholars that provides access to the public.

Section VI. Conclusion

Limitations

Small sample size was the most apparent limitation to this quality improvement project. Seven potential participants were identified. Of those, five participated in the pre-implementation survey and three in the post-implementation survey. One participant was on a scheduled leave of absence during the two-week implementation period and did not complete either survey. In subsequent implementations of this quality improvement project, a larger sample size would be beneficial to obtain results that may then be representative of the population.

A second limitation is the short implementation period. A two-week implementation period was designated to conduct this quality improvement project. During those two weeks, there was zero incidence of LAST at the participating project site. This limited the ability for the LAST QRG to be used in real time to navigate the management of LAST. Participants had to imagine how the LAST QRG would be helpful in an emergent scenario versus using the QRG to assist in direct patient care. Suggestions for QRG improvement was limited, possibly by the time constraint of the implementation period. The participants may have had additional recommendations for improvement after a longer period of time using the QRG. However, since LAST is a rare event, use of the QRG in treatment may also be rare, but its usefulness in preventing LAST cannot be overstated.

Recommendations for Future Implementation

Recommendations for subsequent implementation of this quality improvement project would be to expand both the sample size and the implementation time period. By upscaling the project, data may then be more generalizable and be applicable to facilities outside of the participating project site. A larger sample size should also provide a wide range of experience by CRNAs and possibly more comprehensive feedback to further refine the LAST QRG. A longer timeframe may also improve participation as CRNAs would have greater opportunity to complete the pre- and post- implementation surveys and not feel hurried in the process.

In the re-implementation of the project, a short video added to the emailed PowerPoint Presentation demonstrating the use of the LAST QRG in a real-life scenario may be more memorable for visual learners. A mock scenario could be beneficial to help the participants remember the signs and symptoms of LAST, correct dosages of local anesthetics, and the first steps in the management of LAST while following the protocol laid out in the QRG. To take this concept a step further, an in-person mock scenario using a hands-on approach to identify LAST and how a CRNA in a team setting may manage this emergency would be a beneficial way to interact with participants, get feedback in real time, and educate CRNAs on how to utilize the QRG in their work setting.

This quality improvement project was based on a single PDSA cycle. Future implementation of this project may include multiple PDSA cycles to engage with staff, build buy-in from participants, and further refine the LAST QRG to be used in a larger hospital setting. More data provides the opportunity for a more robust data bank to make comprehensive conclusions. Each PDSA cycle builds upon the last, making the final product potentially more

reliable and sustainable once integrated into the CRNAs' workflow. During subsequent implementations of this project, multiple PDSA cycles will be beneficial.

To improve the LAST QRG for future implementation, a double-sided version with an increased font size is recommended. The current QRG is single sided to allow for the QRG to be posted on a wall or crash cart. This required the font be small enough to include all important information regarding LAST. A double sided QRG will allow for larger font, therefore enhancing readability by the CRNA in an emergent situation. A double sided QRG may increase the monetary cost of printing only marginally. Making these few adjustments to enhance the current LAST QRG and project implementation as a whole could be beneficial to continue improvement in CRNA prevention, identification, and management of LAST.

References

American Association of Nurse Anesthesiology. (2019). Standards of nurse anesthesia practice. https://tinyurl.com/5n7yxdxu

Arumugam, S., Contino, V., & Kolli, S. (2020). Local anesthetic systemic toxicity (LAST) – A review and update. *Current Anesthesiology Reports* (Philadelphia), 10(2), 218-226. https://doi.org/10.1007/s40140-020-00381-x

Drasner, K. (2010). Local anesthetic systemic toxicity: A historical perspective. *Regional Anesthesia and Pain Medicine*, *35*(2), 162-166. https://doi.org/10.1097/AAP.0b013e3181d2306c

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.S154512

Ferguson, W., Coogle, C., Leppert, J., & Odom-Maryon, T. (2019). Local anesthetic systemic toxicity (LAST): Designing an educational effort for nurses that will last. *Journal of Perianesthesia Nursing, 34*(1), 180-187. https://doi.org/10.1016/j.jopan.2018.02.006

Gitman, M., & Barrington, M. J. (2018). Local anesthetic systemic toxicity: A review of recent case reports and registries. *Regional Anesthesia and Pain Medicine, 43*(2), 124-130. https://doi.org/10.1097/AAP.0000000000000721

Institute for Health Care Improvement. (2017). QI Essentials tool kit: PDSA worksheet. https://www.ihi.org/sites/default/files/QIToolkit_PDSAWorksheet.pdf

Macfarlane, A. J. R., 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*(S1), 27-39. https://doi.org/10.1111/anae.15282

Mayer, E. (1923). Preliminary report of the committee for the study of toxic effects of local anesthetics. *The Journal of the American Medical Association, 81*(11), 947-947. https://doi.org/10.1001/jama.1923.02650110077037

Mayer, E. (1924). The toxic effects following the use of local anesthetics: An analysis of the reports of forty-three deaths submitted to the committee for the study of toxic effects of local anesthetics of the American Medical Association, and the recommendations of the committee. *The Journal of the American Medical Association, 82*(11), 876-885. https://doi.org/10.1001/jama.1924.26520370002015c

Melnyk, B. M. & Fineout-Overholt, E. (2019). *Evidence-based practice in nursing: A guide to best practice.* (4th ed., pp. 131). Philadelphia, Wolters Kluwer.

Merkow, R. P., Shan, Y., Gupta, A. R., Yang, A. D., Sama, P., Schumacher, M., Cooke, D., Barnard, C., & Bilimoria, K. Y. (2020). A Comprehensive Estimation of the Costs of 30-Day Postoperative Complications Using Actual Costs from Multiple, Diverse Hospitals. *Joint Commission journal on quality and patient safety*, *46*(10), 558–564. https://doi.org/10.1016/j.jcjq.2020.06.011

Neal, J. M., Neal, E. J., & 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

On'Gele, M. O., Weintraub, S., Qi, V., & Kim, J. (2022). Local anesthetics, local anesthetic systemic toxicity (LAST), and liposomal bupivacaine. *Clinics in Sports Medicine, 41*(2), 303-315. https://doi.org/10.1016/j.csm.2021.12.001

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 treatment. *AANA Journal, 91*(5), 385-391. https://www.proquest.com/scholarly-journals/assessing-crna-knowledge-local-anesthetic/docview/2875352877/se-2

Suzuki, S., Gerner, P., & Lirk, P. (2019). Local anesthetics. In Hemmings, C. Hugh, & T. D. Egan, (Eds.), *Pharmacology and physiology for anesthesia* (pp. 390-411) https://doi.org/10.1016/B978-0-323-48110-6.00020-X

Waldinger, R., Weinberg, G., & Gitman, M. (2020). Local anesthetic toxicity in the geriatric population. *Drugs & Aging, 37*(1), 1-9. https://doi.org/10.1007/s40266-019-00718-0

Appendix A

Literature Concepts Table

	Concept 1 **CRNA**	Concept 2 **Local Anesthetic Systemic Toxicity (LAST)**	Concept 3 **Reference Tool**	Concept 4 **Confidence**
Keywords	“Nurse Anesthetist” “Nurse Anesthesia” “Certified Registered Nurse Anesthetist”	“Local Anesthesia” “Local anesthetics” “Local anesthetic toxicity”	“Hand Guide” “Pocket Guide” “Reference Guide” “Reference tool”	“Confidence” “Assurance” “Certainty” “Increased knowledge”
PubMed MeSH	"Nurse Anesthetists"[Mesh]	(("Anesthetics, Local"[Mesh])) OR "Anesthesia, Conduction"[Mesh]	(("Reference Books"[Mesh]) OR "Handbook" [Publication Type]) OR "Resource Guide" [Publication Type]	"Self-Concept"[Mesh]
CINAHL Subject Headings	(MH "Certified Registered Nurse Anesthetists")	(MH "Anesthetics, Local") OR (MH "Anesthetics, Intravenous") OR (MH "Anesthetics") OR (MH "Anesthetics, Dissociative")	(MH "Reference Tools")	(MH "Confidence") OR (MH "Knowledge")

Google Scholar	(CRNA) OR (nurse anesthetist) OR (nurse anesthesia) OR (certified registered nurse anesthetist)	(LAST) OR (local anesthetics) OR (local anesthesia) OR (local toxicity)	(Reference Guide) OR (reference tool)	(Self-confidence) OR (confidence) OR (knowledge) (Self-confidence) AND (confidence) AND (knowledge)

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
09/09/2024	PubMed	(Local anesthetic systemic toxicity) AND (nurse anesthesia) (("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 ("nurse anesth"[Journal] OR ("nurse"[All Fields] AND "anesthesia"[All Fields]) OR "nurse anesthesia"[All Fields])) AND (y_5[Filter])	5 years (2019-2024) English Language Peer-Reviewed	2/1	Relevant to topic, assessing CRNA knowledge/ not applicable
09/12/24	PubMed	("anesthetics, local" OR "anesthesia, local") AND "anesthetists"	5 years (2019 – 2024) English Language	33/4	Relevant to topic, provides more background information on LAST/not applicable

		(("anesthetics local"[All Fields] OR "anesthesia local"[All Fields]) AND "anesthetists"[All Fields]) AND (y_5[Filter])			
09/12/24	PubMed	("anesthesia, local" OR "anesthetics, local") AND (nurse anesthesia) (("anesthesia local"[All Fields] OR "anesthetics local"[All Fields]) AND ("nurse anesth"[Journal] OR ("nurse"[All Fields] AND "anesthesia"[All Fields]) OR "nurse anesthesia"[All Fields])) AND (y_5[Filter])	5 years (2019-2024)	34/4 Cross over noted between this current search and the search above	Relevant to topic, provides more background information on LAST/not applicable
09/09/2024	CINAHL	((MH "Certified Registered Nurse Anesthetists") AND (MH "Anesthetics, Local") OR (MH "Anesthetics, Intravenous") OR (MH "Anesthetics") OR (MH "Anesthetics, Dissociative")	5 years (2019-2024) English Language Peer-Reviewed	60/1	Relevant to topic, education tools used for nurses on LAST/not applicable
09/09/2024	Google Scholar	(CRNA) OR (nurse anesthetist) OR (nurse anesthesia) OR (certified registered nurse anesthetist) AND (LAST) OR (local anesthetics) OR (local anesthesia) OR (local toxicity) AND (Reference Guide) OR (reference tool)	5 years (2019 -2024)	113 pages/1 page kept (20 pages reviewed)	Specific to nurse anesthesia, relevant to topic/not applicable

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/Notes
2023	Tkach, L., Baillie, L., Newby, J., O'Guin, C., Dalley, C. B., Crowell, N., PhD., & Eshkevari, L., (2023). Assessing CRNA knowledge of local anesthetic systemic toxicity treatment. AANA Journal, 91(5), 385-391. https://www.proquest.com/scholarly-journals/assessing-crna-knowledge-local-anesthetic/docview/2875352877/se-2	2 aims of study: to assess CRNA knowledge of LAST management put forth by ASRA treatment guidelines and to determine relationship between perioperative local anesthetic use and their knowledge level.	Quantitative description study and survey Level of Evidence: VI	Hospital setting Practicing CRNA's who are active members of AANA	Out of 3,000 possible respondents, 184 CRNAs participated in the survey. (Response rate of 6.1%)	IRB Approval from Georgetown University Survey administered via SurveyMonkey Used G*Power 3.1.9.7 to calculate a minimum sample size of 84 to obtain a power of 0.80, alpha of 0.05, and a medium effect size.	23% (n = 43) reported a lack of immediate guideline access 97.87% identified the importance of early administration of lipid emulsion Higher knowledge scores reported in those who had access to written/electronic guidelines. access (P = .049). Evidence that cognitive aids help to bridge the knowledge gap. I.e. our pamphlet/ quick reference guide will be useful to CRNA's at ECUHMC.

2021	Macfarlane, A. J. R., 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(S1), 27-39. https://doi.org/10.1111/anae.15282	Full proposed LAST pathway for management.	Literature Review Level of Evidence: VI	Perioperative	Literature Review, not specific	Literature Review	Includes full diagram for LAST management pathway and key points with color coding. 20% Lipid Emulsion Therapy treatment explanation and reasoning.
2021	Neal, J. M., Neal, E. J., & 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	Checklist put forth by ASRA for LAST management	Expert Opinion Level of Evidence: VII	Peri-operative	N/A	N/A	Update to practice advisory on LAST. ASRA LAST Management Checklist
2020	Arumugam, S., Contino, V., & Kolli, S. (2020). Local anesthetic systemic toxicity (LAST) – a review and update. Current Anesthesiology Reports (Philadelphia), 10(2), 218-226. https://doi.org/10.1007/s40140-020-00381-x	Increase provider knowledge of LAST, especially lipid emulsion therapy. Gives overview in different populations of patients.	Literature Review Level of Evidence: VI	Peri-operative	N/A	N/A	Lidocaine related events have increased About half of reported cases of LAST have received lipid infusions. Possible to see better outcomes if providers are more aware of the benefits of lipid infusion rapidly.

2019	Ferguson, W., Coogle, C., Leppert, J., & Odom-Maryon, T. (2019). Local anesthetic systemic toxicity (LAST): Designing an educational effort for nurses that will last. *Journal of Perianesthesia Nursing, 34*(1), 180-187. https://doi.org/10.1016/j.jopan.2018.02.006	Increase knowledge of LAST in RN's who assist anesthesia providers during the use of local anesthetics to the management of LAST	Evidence-Based Practice; Quality Improvement Level of Evidence: VI	Level II trauma center, 292-bed community owned hospital in Northern Idaho, perioperative setting	Educational intervention was provided to 70 RNs in the peri anesthesia settings	Literature Review utilizing the following databases: CINHAL, PubMed, ERIC, MedLine, Joanna Briggs Institute, Cochrane Library, and PsycINF	Findings demonstrated a knowledge deficit in RN's. The average of all three units combined pretest scores was 60% and post-test scores increased to 95%. Proves that educational tools can impact knowledge bases. (i.e. our pamphlet should have an impact on the CNRA's perceived knowledge of LAST)
2019	Suzuki, S., Gerner, P., & Lirk, P. (2019). Local anesthetics. In Hemmings, Hugh C., MD, PhD, FRCA, & T. D. Egan MD (Eds.), Pharmacology and physiology for anesthesia (Second ed., pp. 390-411) https://doi.org/10.1016/B978-0-323-48110-6.00020-X	Pharmacology and Physiology of LA. Great background information and understanding of local anesthetics.	Expert, Textbook Chapter Level of Evidence: VII	Hospital	N/A	N/A	Pharmacology and Physiology of local anesthetics for background on pharmacokinetics and pharmacodynamics Supports dosing guidelines included in tool
2018	Gitman, M., & Barrington, M. J. (2018). Local anesthetic systemic toxicity: A review of recent case reports and registries. Regional Anesthesia and Pain Medicine, 43(2), 124-	Most common signs and symptoms of LAST seen across the literature	Literature Review Level of Evidence: VI	Peri-operative	47 LAST cases were described in 35 peer-reviewed articles	Review of clinical registries	Most common feature = seizure (53% and 61% from case reports and registries) Incidence of LAST reported in registries

	130. https://doi.org/10.1097/AAP.0000000000000721						is 0.03% or 0.27 per 1000 peripheral nerve blocks Supports signs and symptoms to be aware of which are included in tool
2018	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.S154512	Multifactorial mechanisms of LAST explained. Increase knowledge of risk factors and treatment of LAST for clinicians.	Literature Review, Expert Opinion Level of Evidence: VI	Peri-operative	N/A	N/A	LAST = life threatening event. Increase in knowledge of LAST will help increase positive outcomes Supporting evidence for increased knowledge of LAST to improve clinical practice

Appendix D

Approval Processes

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. 11/16/2024

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: umcirb@ecu.edu.

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	Assessing CRNA Perceptions of a Cognitive Aid Regarding Local Anesthetic Systemic Toxicity: A DNP Project
Project Leader	Cordelia Rios, SRNA
Project Leader Contact E-mail	[redacted]
Department or Unit Affiliation	Anesthesia Department
Project Advisor (if applicable)[1]	[redacted]

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, SRNA	Anesthesia	Student Project Team Member	☐
Mary Elise Pierce, SRNA	Anesthesia	Student Project Team Member	☐
Dalton Henderson, SRNA	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 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, such as this projects quality improvement LAST reference tool, can aid in anesthesia provider confidence when in an emergency situation. This project will be deemed successful if the newly developed cognitive aid is well-received and increases CRNA 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.]

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, Cordelia Rios, 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 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. Ferguson, W., Coogle, C., Leppert, J., & Odom-Maryon, T. (2019). Local anesthetic systemic toxicity (LAST): Designing an educational effort for nurses that will last. *Journal of Perianesthesia Nursing, 34*(1), 180-187. https://doi.org/10.1016/j.jopan.2018.02.006		
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	Lynnette Atkinson
Signature	Signed by: [redacted] 5AB2E7BD53674F0...
Date	2/6/2025 | 11:14 AM 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 qualityimprovement@ecu.edu.

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: umcirb@ecu.edu.

☒ **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

LAST Quality Reference Guide (QRG) and PowerPoint Presentation with Transcript

ECU COLLEGE OF NURSING

Local Anesthetic Systemic Toxicity (LAST) Reference Tool

Cordelia 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

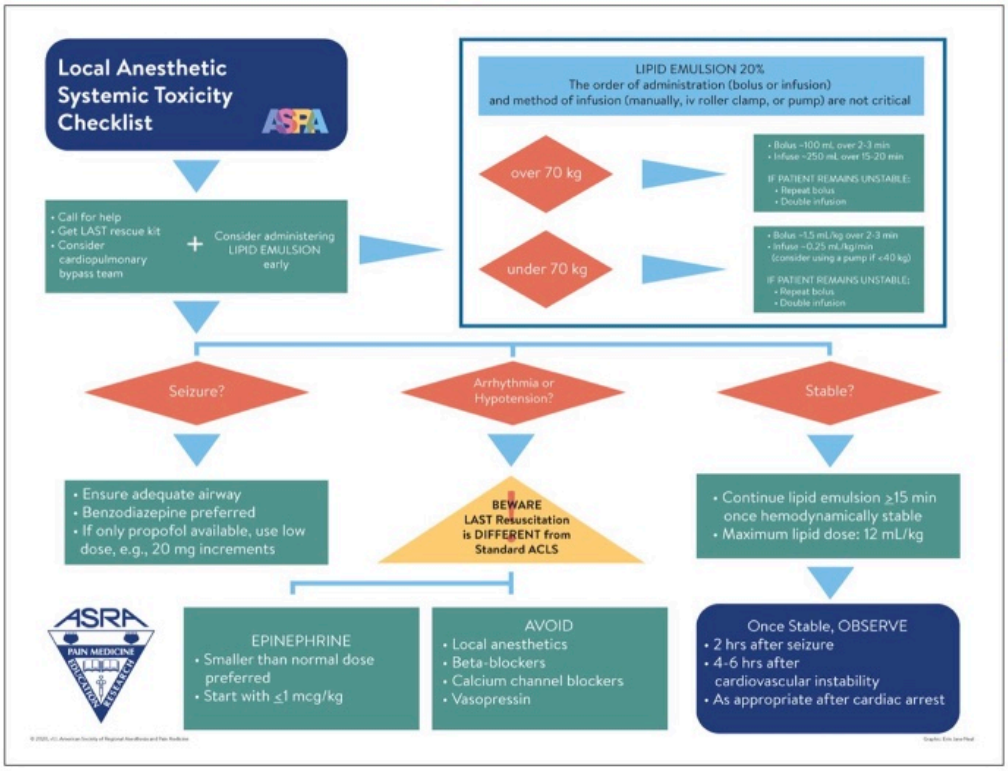
CNS signs and symptoms are more common than CV. **Seizures is the MOST common.**

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

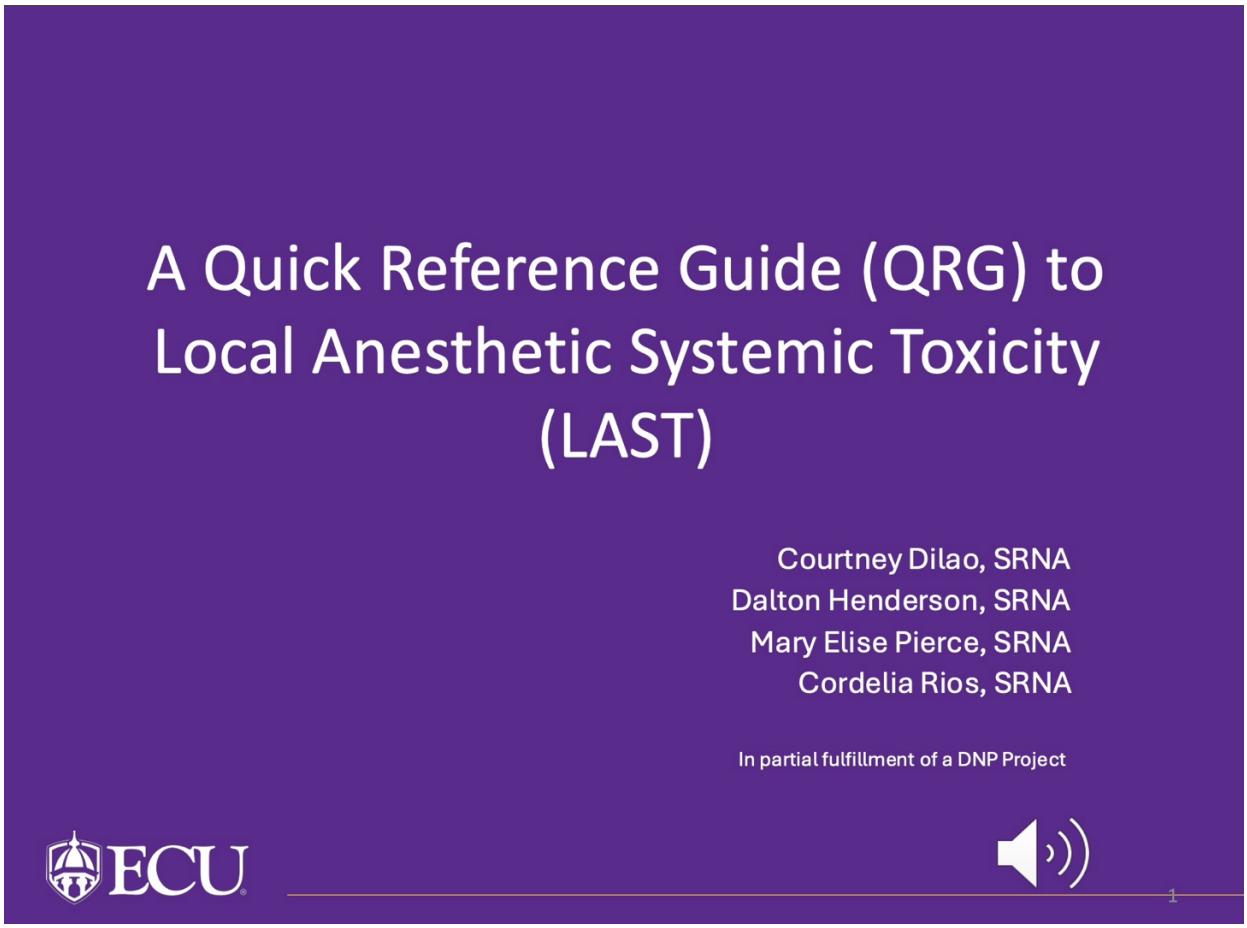
B = blood/bronchial
I = intercostal
C = caudal
E = epidural
P = plexus (brachial)
S = sciatic
S = subcutaneous

Reference

El-Boghdadly, K., Bailey, A., & Chin, K. J. (2018). Local anesthetic systemic toxicity: current perspectives. Local and regional anesthesia, 11, 35–44. https://doi.org/10.2147/LRA.S154512

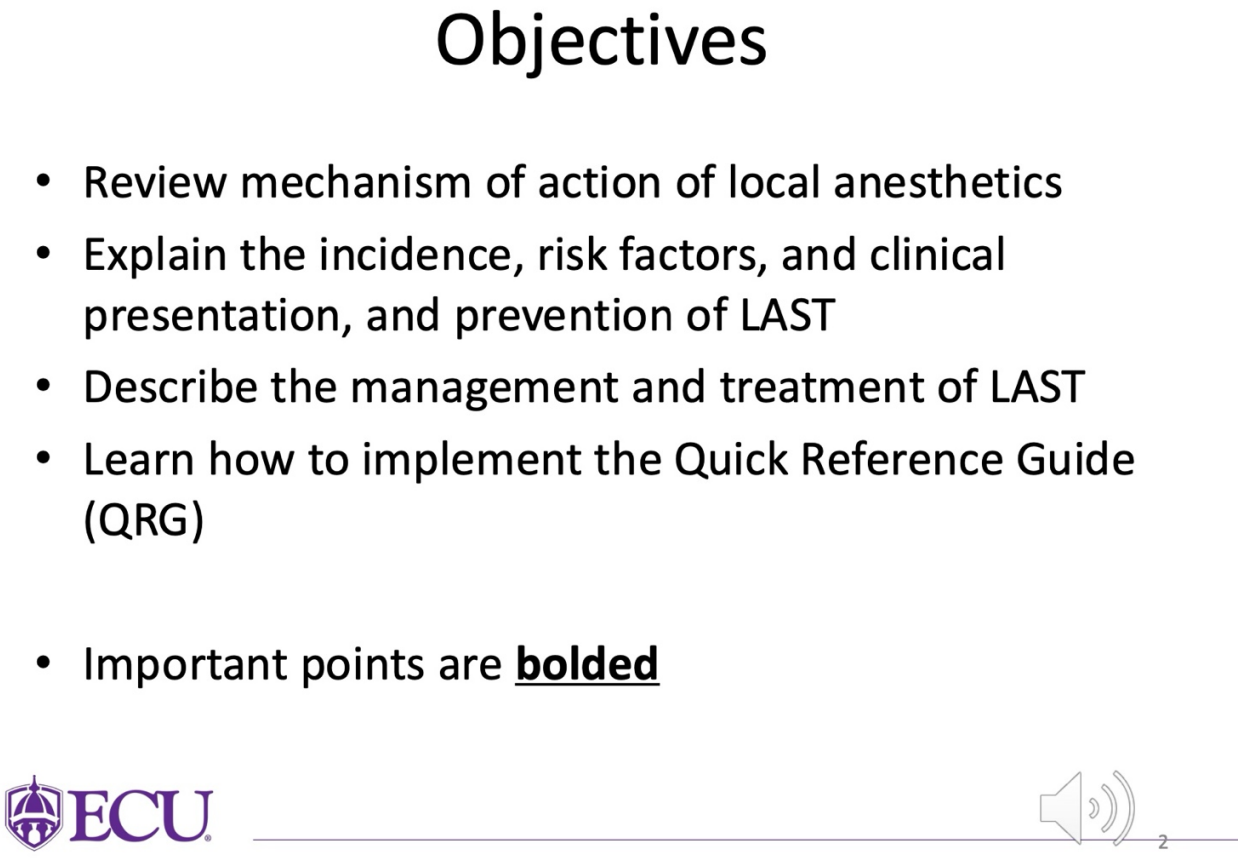
Kodali, R.N. (2013). Chapter 120. Local anesthetics and adjuvants. Atchabahian A, & Gupta R(Eds.), The Anesthesia Guide. The McGraw-Hill Companies. https://accessanesthesiology.mhmedical.com/content.aspx?bookid=572&sectionid=42543709

Neal, J. M., Neal, E. J., & 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

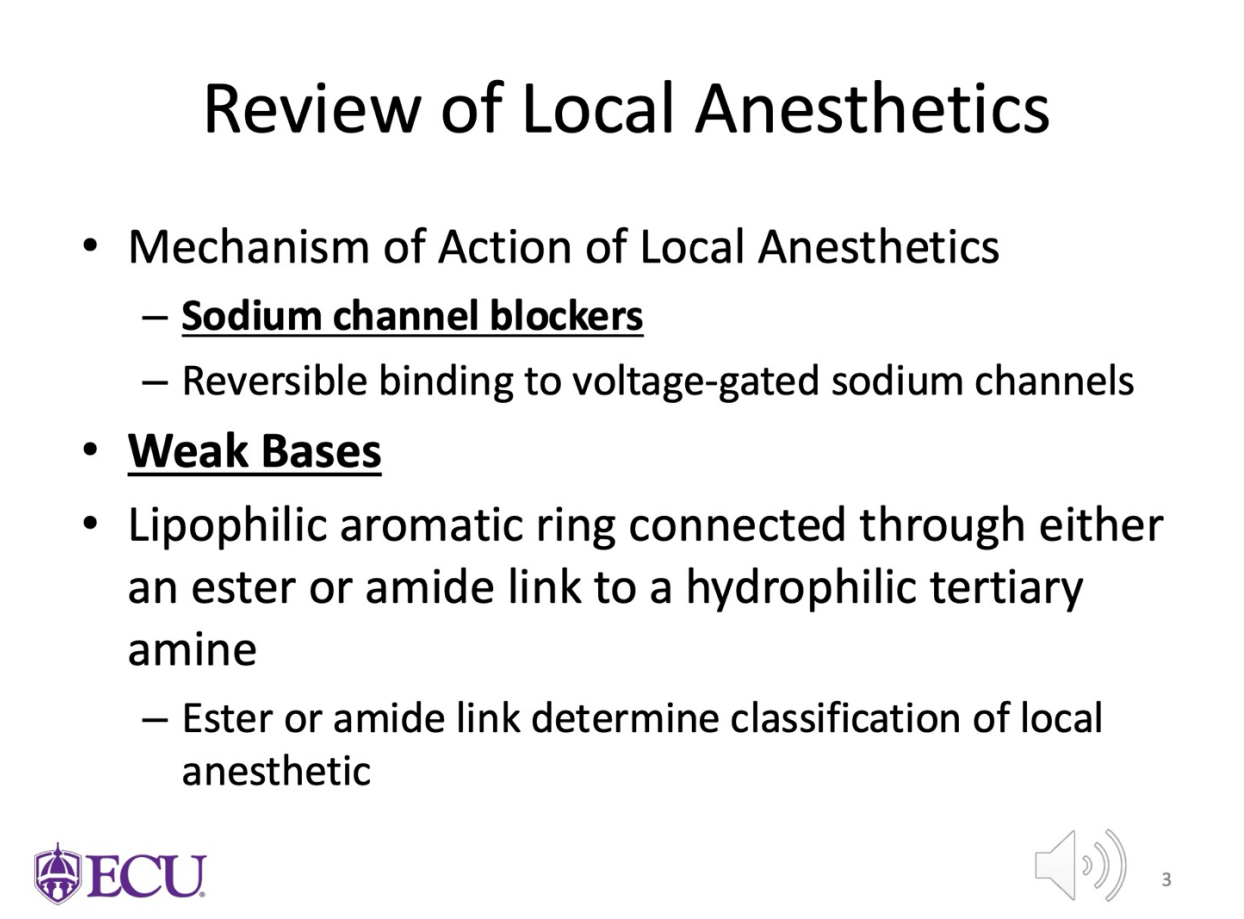


Slide 1 Transcript: Thank you for taking a few minutes to review this PowerPoint Presentation titled “A Quick Reference Guide to Local Anesthetic Systemic Toxicity.” This presentation was compiled in partial fulfillment of a DNP project by Courtney Dilao, Dalton Henderson, Mary Elise Peirce, and Cordelia Rios.

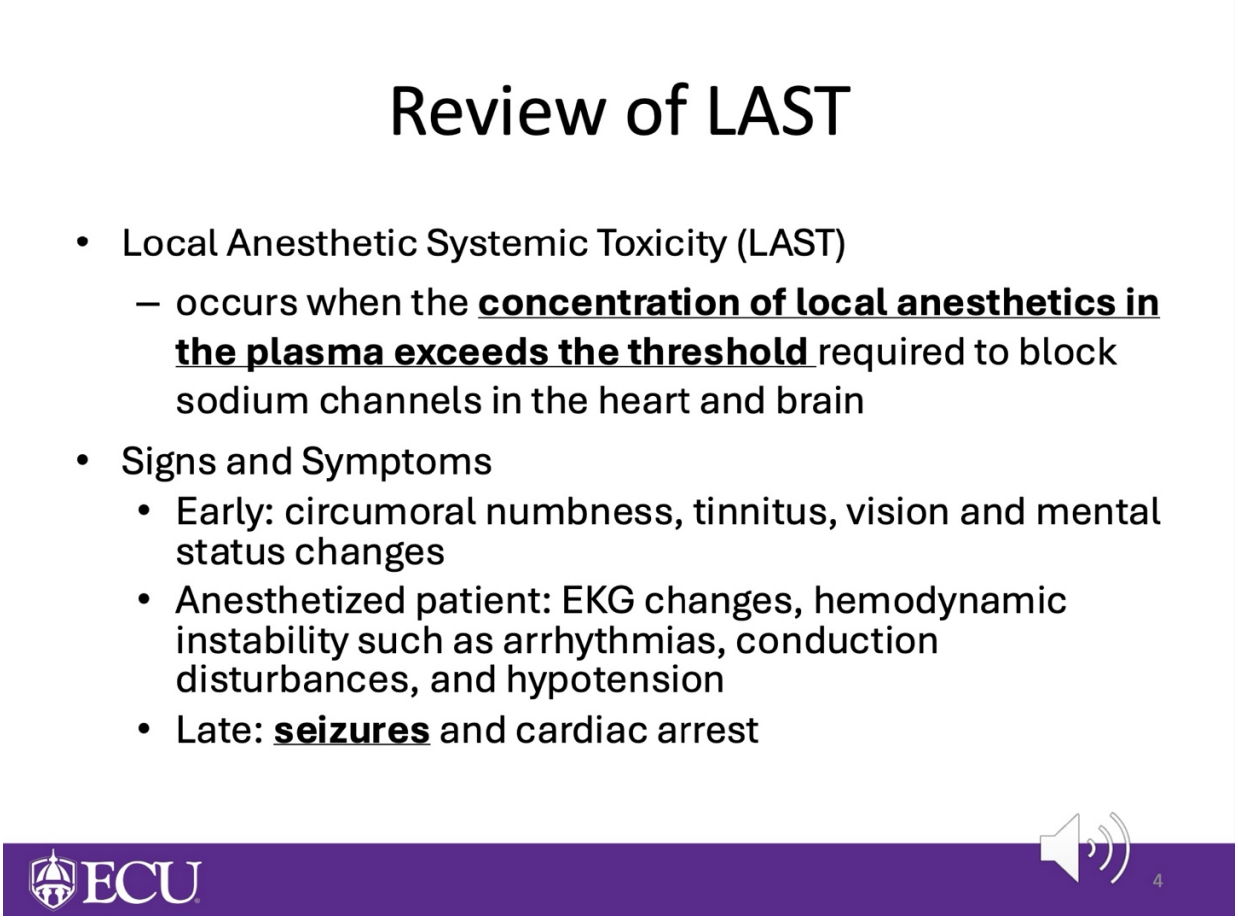
This PowerPoint is 14 slides and should take about 10 minutes review. Important points are underlined and bolded for your convenience.



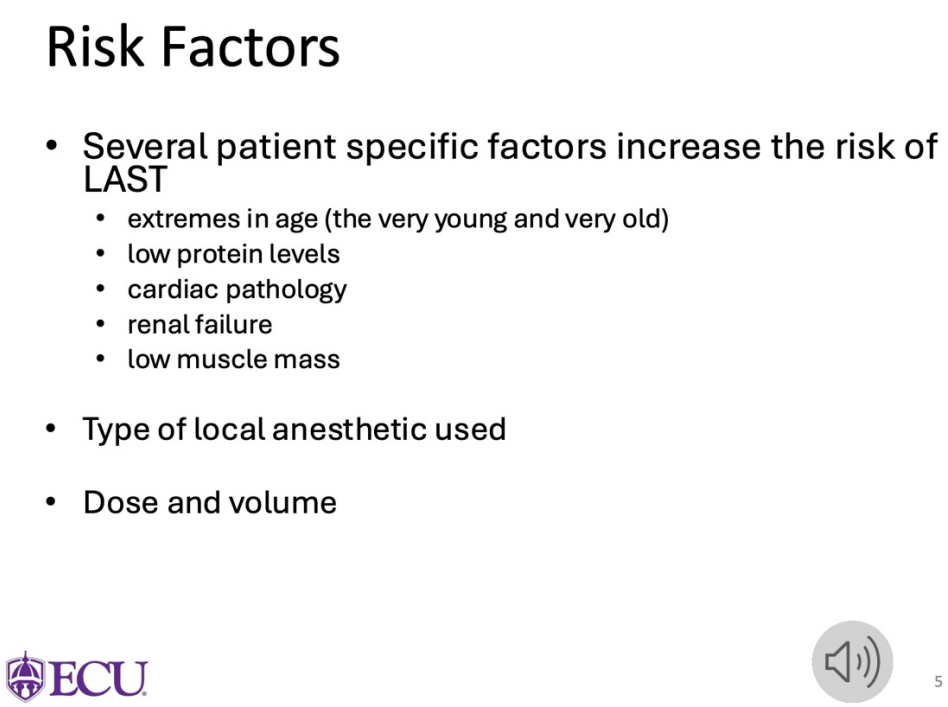
Slide 2 Transcript: This PowerPoint presentation will aim to quickly: review mechanism of action of local anesthetics, explain the incidence, risk factors, and clinical presentation, and prevention of LAST, describe the management and treatment of LAST, and finally, you will learn how to implement the Quick Reference Guide (from here on abbreviated as QRG) created by this group of SRNAs.



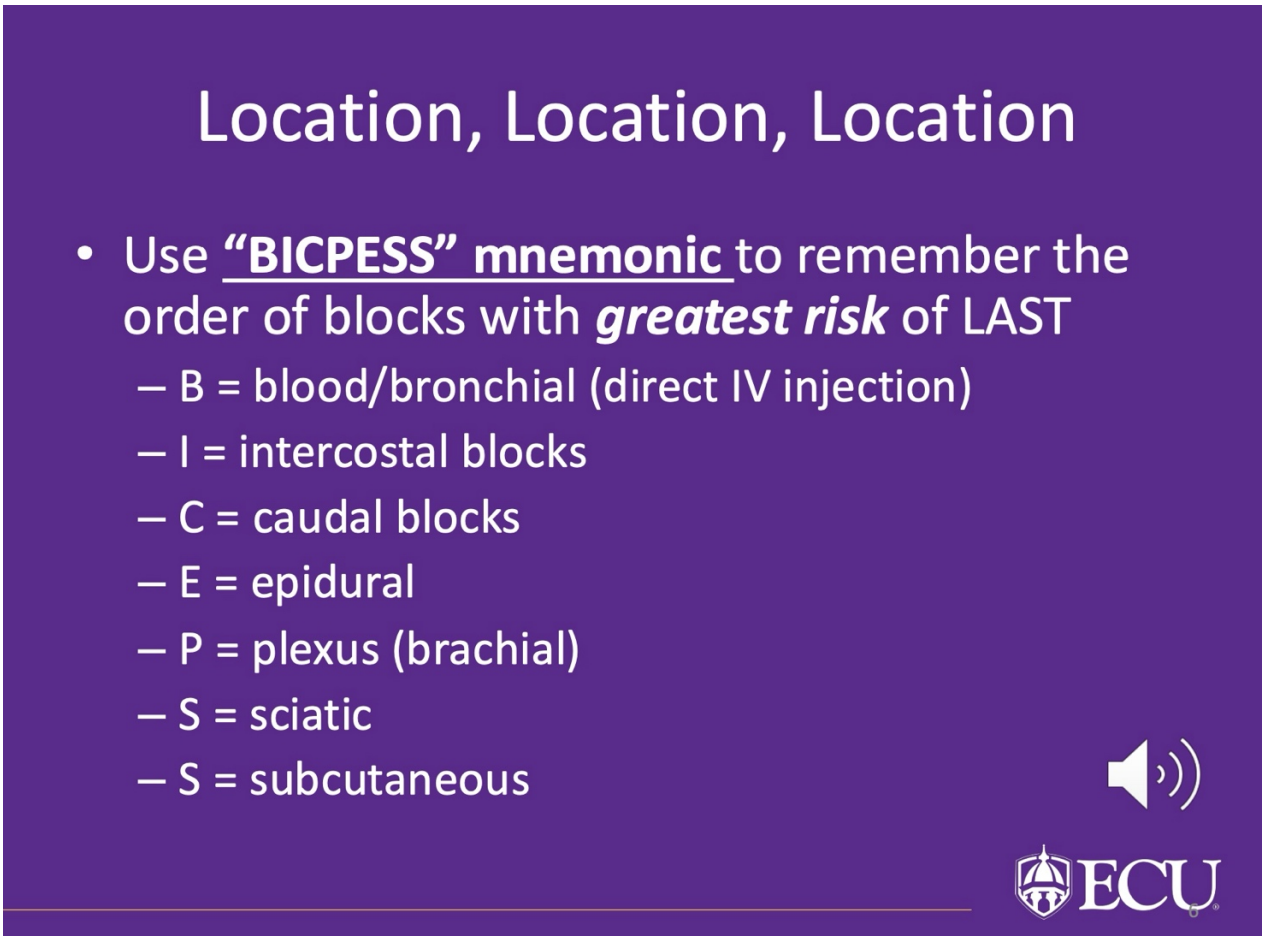
Slide 3 Transcript: Local anesthetic mechanism of action is through reversible binding to voltage-gated sodium channels along nerve axons to inhibit the transduction of a nerve impulse. Local anesthetics bind to voltage-gated sodium channels during the activated and inactivated state, but not during the channels' resting state. Local anesthetics are weak bases with a common lipophilic aromatic ring connected through either a carboxylic ester or amide to a hydrophilic tertiary amine (Arumugam et al., 2020). Why that matters is because the amino ester or amino amide link determine the classification of the local anesthetics and how the anesthetic is metabolized. Although local anesthetics have similar structures, they differ in their distinct pKa, lipid solubility, and protein binding, which alters their clinical effect.



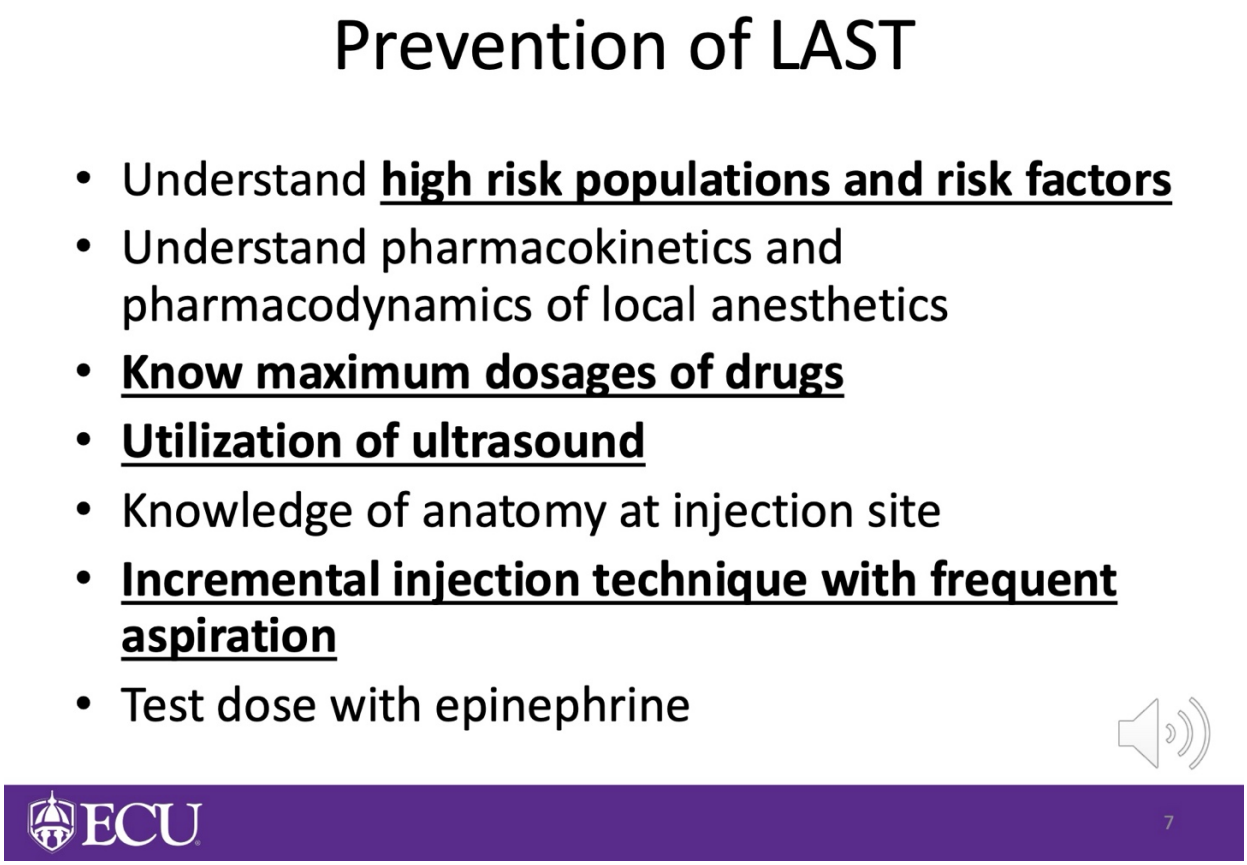
Slide 4 Transcript: Local Anesthetic Systemic Toxicity (LAST) occurs when the concentration of local anesthetics in the plasma exceeds the threshold required to block sodium channels in the heart and brain. When this occurs, the heart and brain enter a state of oxidative metabolism. This leads to an anaerobic state and inhibits mitochondrial activity, causing the symptoms of LAST. Early symptoms are noticeable in the awake patient: circumoral numbness, tinnitus, vision and mental status changes. In the anesthetized patient, the earliest signs of toxicity will be seen in the EKG and hemodynamics of the patient: arrhythmias, conduction disturbances, and hypotension. Late stages of LAST include seizures and cardiac arrest



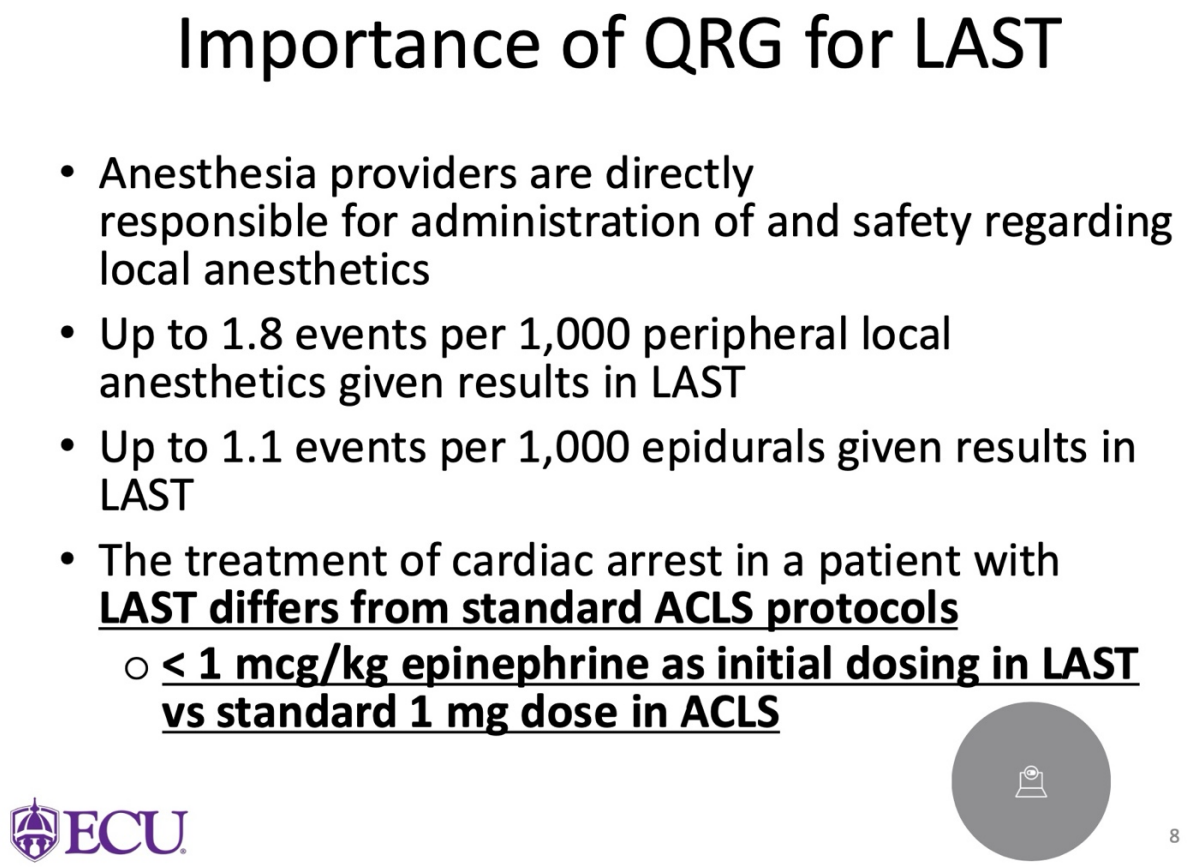
Slide 5 Transcript: Patient specific factors that increase the risk for developing LAST include extremes of age, low protein levels, cardiac pathologies or comorbidities, renal failure, and low muscle mass. Both the elderly and infants and neonates have low protein levels and low muscle mass. Additionally, the type of local anesthetic used may increase the risk because there is a link between potency and toxicity. Another risk factor that deals with the drug itself is the dose and volume. Both increased dose and increased volume place the patient at higher risk for developing LAST.



Slide 6 Transcript: Just like in real estate, location also matters when thinking about LAST. The location of the block impacts the rate of systemic absorption. Use "BICPESS" mnemonic to remember the order of blocks with greatest risk of LAST. Risk for systemic absorption is ranked by location from greatest to least as follows: intravenous, intercostal, caudal, epidural, brachial plexus, sciatic nerve, and subcutaneous injection



Slide 7 Transcript: “An ounce of prevention is worth a pound of cure.” The goal of an anesthesia provider is continuous patient safety through treatment. For the anesthesia provider to prevent an incident of LAST, they must: Understand high risk populations and risk factors, understand the pharmacokinetics and pharmacokinetics of local anesthetics, know maximum dosages of local anesthetics, utilization of ultrasound allows direct visualization of anatomy and timely identification of intravascular injection, knowledge of anatomy at injection site, incremental injection technique, addition of pharmacologic markers, such as epinephrine in a test dose. If the injection is intravenous, immediate increase in HR and BP will be seen. A table of dosages can be found on the upcoming slide. Feel free to take a photo or screenshot and save to your camera roll for later reference.



Slide 8 Transcript: It is the direct responsibility of anesthesia providers to administer and monitor for the effects of local anesthetics. LAST is not an overtly rare event, occurring in almost 2 out of every 1,000 individuals who receive peripheral local anesthetics, and 1.1 per 1,000 individuals who receive an epidural. In times of stress, it is easy to forget the details of treatment and prevention regarding specific therapies. Local anesthetic systemic toxicity is not treated with standard ACLS protocol. Where ACLS calls for 1 mg of epinephrine at each administration, LAST calls for less than 1 mcg/kg as the initial dosing along with the prompt administration of intralipids. Intralipids will be discussed later in this presentation.

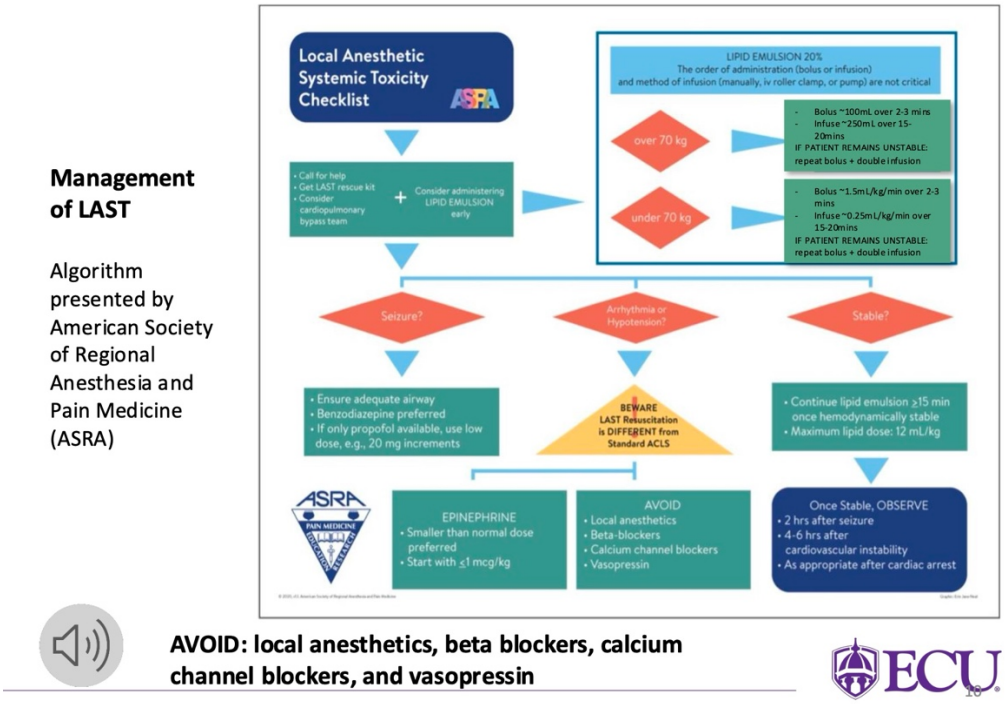
The importance of this QRG is that it provides an easy way to define LAST, methods of LAST prevention, and the American Society of Regional Anesthesia and Pain Medicines checklist for LAST treatment, all in one easy to reach place.

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

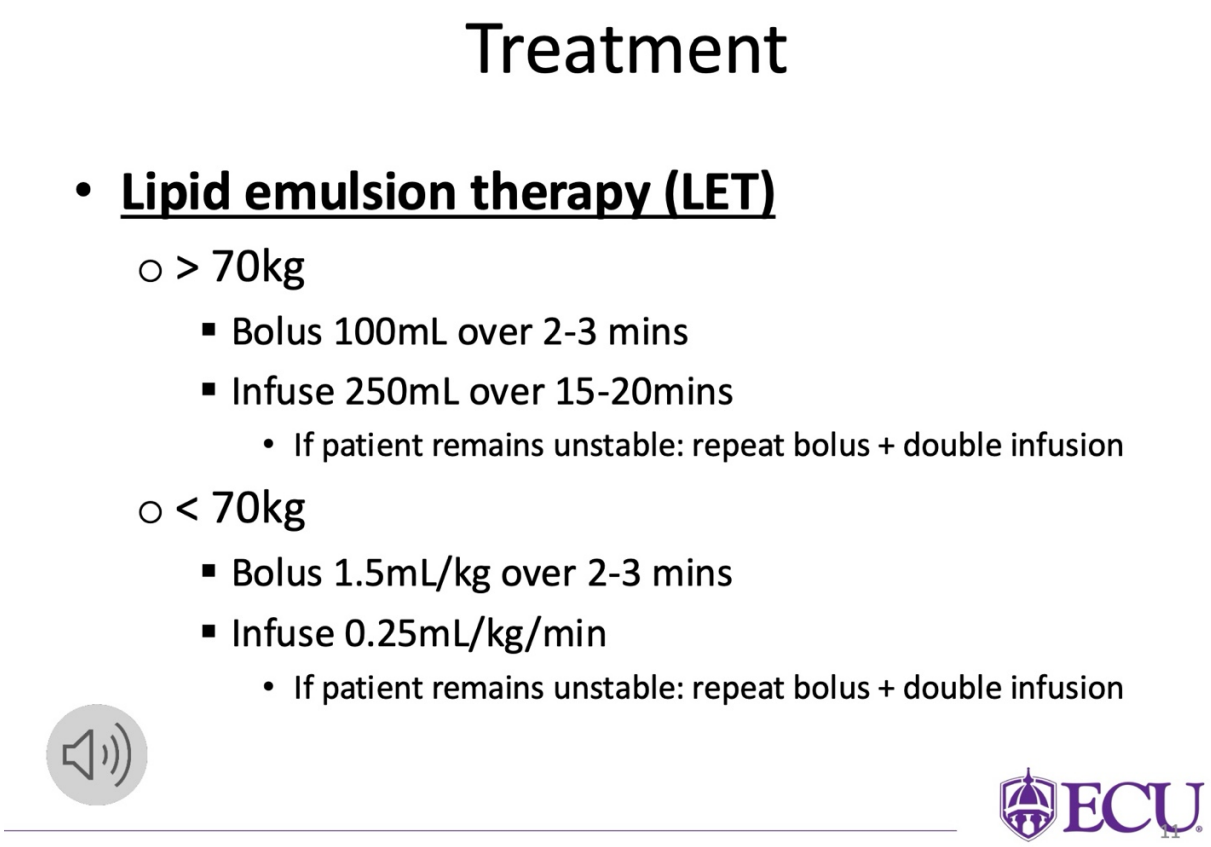
9

Slide 9 Transcript: Here is a table of Maximum Recommended Doses of Local Anesthetics with and without epi. Feel free to take a photo or screenshot and save to your camera roll for later reference in your practice. This table can also be found on the provided QRG

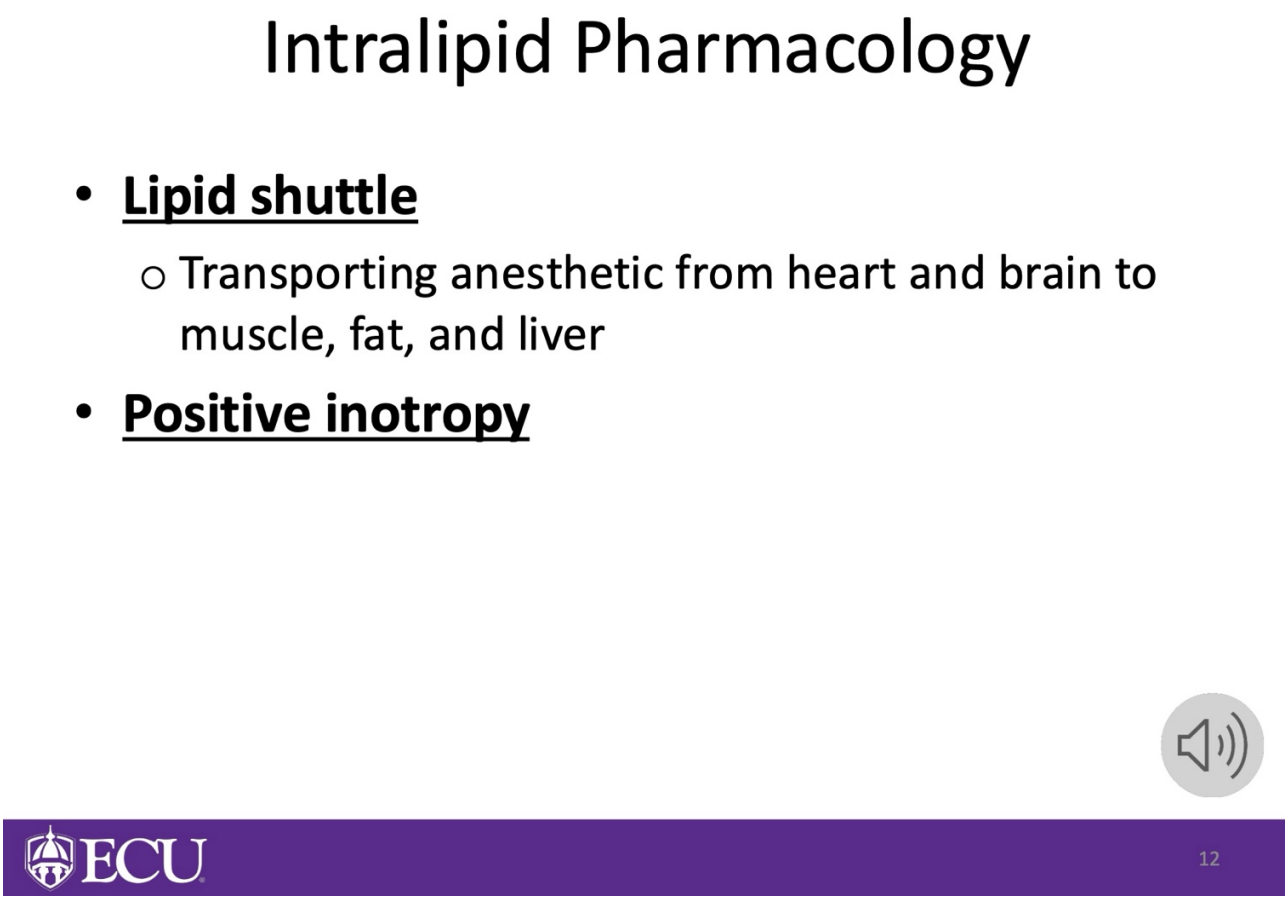


Slide 10 Transcript: The American Society of Regional Anesthesia and Pain Medicine released their 2020 Local Anesthetic Systemic Toxicity checklist. This algorithm can be found in our QRG for your reference. We will briefly go over it. The treatment for last is lipid emulsion therapy or LET. If the patient has a seizure, you want to maintain the airway and administer benzodiazepines. Propofol is not indicated because it can augment myocardial depression. If this is the only drug you have available, the ASR recommends low doses in 20 mg increments. If your patient has an arrhythmia or hypotension, there are some things that are different from standard ACLS that we want to discuss Your epinephrine dose will be smaller than the ACLS dose and you will start with less than one microgram per kilogram to treat hypotension. Some drugs to avoid include additional local anesthetic, beta blockers, calcium channel blockers, and vasopressin. Once your patient is stable, you can continue the lipid emulsion therapy. You want

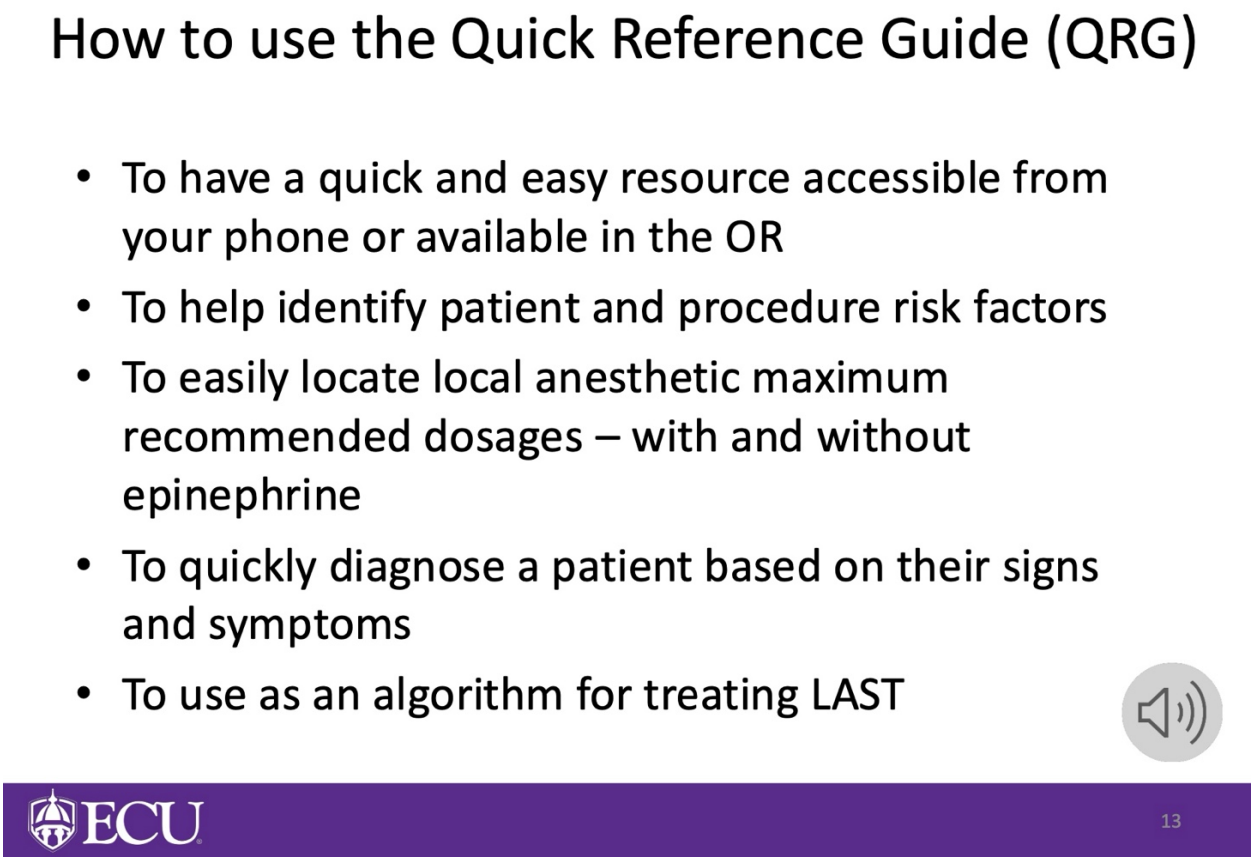
to observe them two hours after any seizure activity and 4 to 6 hours after any cardiovascular instability.



Slide 11 Transcript: The treatment for LAST is lipid emulsion therapy or LET. If your patient is over 70 kg you will administer a bolus of 100 mls over 2 to 3 minutes, followed by an infusion of 250 mls over 15 to 20 minutes. If your patient is under 70 kg, you will administer a bolus of 1.5 mls per kilogram over 2 to 3 minutes, followed by an infusion of 25 mls per kilogram per minute. If your patient remains unstable after the LET administration repeat the bolus and double the infusion.



Slide 12 Transcript: As previously mentioned, LET is the recommended treatment for LAST by the American Society of Regional Anesthesia and Pain Medicine. The primary actions of the LET are twofold. Firstly, LET acts indirectly as a lipid shuttle — transporting the local anesthetic from organs with high blood flow, such as the heart and brain, to the liver, muscle, and adipose tissue for detoxification. Secondly, LET directly has a positive inotropic effect on the heart. This helps to reverse the myocardial depression, QT and QRS prolongation caused by toxic levels of intravascular injection of LAs.



Slide 13 Transcript: Ways to use the quick reference guide are as follows: to have a quick and easy resource accessible from your phone or available printed out in the OR, to help identify patient and procedure risk factors for developing LAST, to easily locate local anesthetic maximum recommended dosages – with and without epinephrine, to quickly diagnose a patient based on their signs and symptoms, to use as an algorithm for treating LAST, or to brush up your knowledge on the general prevention, diagnosis, and treatment of local anesthetic systemic toxicity. We hope you find our quick reference guide helpful to your practice.

Slide 14 Transcript: Thank you for your dedication and time spent helping us with our DNP project! We are grateful for your assistance and your expertise. Please feel free to utilize the QR code on the slide to quickly access the QRG. Thank you again, This project wouldn't have been possible without you.

Appendix F

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

Dear [redacted],

Thank you for considering participating in a quality improvement project titled "Assessing CRNA Perceptions of a Cognitive Aid Regarding Local Anesthetic Systemic Toxicity: A DNP Quality Improvement Project". The purpose of this project is to assess CRNA perceptions of the adequacy of a LAST Quick Reference Guide (QRG) 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 quality improvement projects aimed at improving this rare but potentially catastrophic preoperative event at the SurgiCenter.

Participation is voluntary and will involve completing a short pre-intervention survey, viewing a brief narrated PowerPoint presentation, utilizing a LAST QRG 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 should take less than 2-4 minutes to complete. The surveys were created and are completed using Qualtrics® survey software. The use of LAST QRG 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-implementation survey provided by clicking the link here.

Following completion of the survey, view the PowerPoint Presentation provided as an attachment to this email for more details concerning Local Anesthetic Systemic Toxicity and this quality improvement project. The LAST Quality Reference Guide is available in the anesthesia work room.

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

Sincerely,
Cordelia Rios, SRNA, walkerc16@students.ecu.edu
Maura McAuliffe PhD, CRNA, FAAN, Project Chair, mcauliffem@ecu.edu

Cordelia Rios, BSN, SRNA
East Carolina University
DNP Nurse Anesthesia, Class of 2026

Pre-Survey Reminder Email (2)

Good morning, [redacted]

I just wanted to send a quick reminder about the ongoing DNP Project on Local Anesthetic Systemic Toxicity (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 LAST Quick Reference Guides located in the anesthesia work room if you haven't already received one. You may use these at your discretion. At the end of the week, I will begin sending out the post-surveys. Please stay tuned for that!

Link:

Pre-survey

PowerPoint Attached to this email.
Please let me know if you have any questions and thank you again for your participation.

Sincerely,

Cordelia Rios, BSN, SRNA
East Carolina University
DNP Nurse Anesthesia, Class of 2026

Post-Survey Email (3)

Dear [redacted],

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

If you have not filled out a pre-survey, I would really and truly appreciate your participation (it's just surveys and a short presentation). The LAST Quality Reference Guide located in the anesthesia workroom 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 and for being excellent preceptors. I look forward to coming back to the SurgiCenter soon.

Sincerely,

Cordelia Rios, BSN, SRNA
ECU Nurse Anesthesia Program
Class of 2026

Email of Thanks to Participants (4)

Dear [redacted]

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 in your daily practice.

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

All my best,

Cordelia Rios, BSN, SRNA
ECU Nurse Anesthesia Program
Class of 2026

Appendix G

Pre- and Post-Implementation Qualtrics Survey Questionnaire

LAST Pre-survey

Q1 How long have you been a practicing Certified Registered Nurse Anesthetist (CRNA)?

- o Less than 1 year
- o 1-4 years
- o 5-10 years
- o Greater than 10 years

Q2 How often do your patients receive local anesthetics (IV administration and/or regional) in your daily practice as a CRNA?

- o Daily
- o Weekly
- o Monthly
- o Rarely

Q3 How familiar are you with local anesthetic systemic toxicity (LAST)?

- o Not familiar at all
- o Somewhat familiar
- o Moderately familiar
- o Very familiar

Q4 How confident are you in identifying high risk populations for LAST?

- o Not at all confident
- o Somewhat confident
- o Moderately confident

o Very confident

Q5 How confident are you in the diagnosis and treatment of LAST?

o Not at all confident

o Somewhat confident

o Moderately confident

o Very confident

Q6 Are you familiar with the mnemonic BICEPSS indicating blocks at highest risk of LAST?

o Not familiar at all

o Somewhat familiar

o Moderately familiar

o Very familiar

Q7 In addition to being a lipid shuttle, the second main mechanism of action of lipid emulsion therapy (LET) includes:

o Alpha receptor agonist

o Beta receptor agonist

o Positive inotropic agent

o DNA synthesis inhibitor

Q8 How confident are you with dosing LET for treating LAST?

o Not at all confident

o Somewhat confident

o Moderately confident

o Very confident

Q9 How familiar are you with the location of where lipid emulsion therapy is stored in the perioperative area at your facility?

- o Not familiar at all
- o Somewhat familiar
- o Moderately familiar
- o Very familiar

Q10 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?

- o Not at all confident
- o Somewhat confident
- o Moderately confident
- o Very confident

Q11 How familiar are you with the drugs to avoid with a patient diagnosed with LAST?

- o Not familiar at all
- o Somewhat familiar
- o Moderately familiar
- o Very familiar

<u>LAST Post-survey</u>

Q1 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?

- o 0
- o 1-5

- o 6-10
- o 11-15
- o >15

Q2 During the last two weeks how many surgical cases that involved the use of local anesthetics did you identify as high risk for LAST?

- o 0
- o 1-5
- o 6-10
- o 11-15
- o >15

Q3 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?

- o Not at all useful
- o Somewhat useful
- o Moderately useful
- o Very useful

Q4 In addition to being a lipid shuttle, the second main mechanism of action of lipid emulsion therapy (LET) includes:

- o Alpha receptor agonist
- o Beta receptor agonist
- o Positive inotropic agent
- o DNA synthesis inhibitor

Q5 How confident are you in your knowledge of the maximum allowable doses of local anesthetics, specifically Bupivacaine, ropivacaine, and lidocaine with and without epinephrine?

- o Not at all confident
- o Somewhat confident
- o Moderately confident
- o Very confident

Q6 How familiar are you with the drugs to avoid with a patient diagnosed with LAST?

- o Not familiar at all
- o Somewhat familiar
- o Moderately familiar
- o Very familiar

Q7 During the last two weeks did this Quality Reference Guide (QRG) improve your awareness of LAST?

- o Yes
- o No
- o No change

Q8 During the last two weeks, while having access to the QRG, how confident were you in diagnosing and treating LAST?

- o Not at all confident
- o Somewhat confident
- o Moderately confident
- o Very confident

Q9 Do you support implementing a LAST QRG at your facility?

o Strongly oppose

o Oppose

o Neural

o Support

o Strongly support