Local Anesthetic Systemic Toxicity Prevention Recognition and Treatment in a Perioperative Setting: A Quality Improvement Project and DNP Project

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Notes from the Author

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Abstract

Local and regional anesthesia provides a benefit to patients in the perioperative period by allowing for surgical procedures to be performed, preventing and treating post-operative pain, and suppressing pain for up to three days. Local Anesthetic Systemic Toxicity (LAST) is a potentially fatal complication of inadvertent systemic absorption of local anesthetics. CRNAs have a crucial role in administering local anesthesia and preventing or treating LAST. The purpose of this DNP QI project was to develop and assess CRNA perceptions of a new quick reference guide (QRG) on LAST treatment and prevention. This quality improvement project was conducted in the main operating room area of a level one trauma hospital in Eastern United States. A single Plan-Do-Study-Act cycle was completed employing a pre- and post-implementation survey design that assessed CRNAs' perception of the QRG. The CRNAs reported an overall positive perception of the QRG. Most of the CRNAs responded that the BICEPSS mnemonic was useful. There was a generalized increase in confidence of knowing maximum dosages of local anesthetics when the QRG was used. Most of the CRNAs supported implementation of the QRG, or one like it, at the partnering organization. Limitations of the study included small sample size, and unique division of the anesthetic workload at the partnering organization. Recommendations for future QI projects in this area include individualized QRG development for the organization, a larger sample size, and involvement of non-CRNA anesthesia providers.

Keywords: LAST, CRNA, Anesthesia, Guide

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Section I. Introduction

Background

The use of local anesthetics as an adjunct to surgical and procedural anesthesia is becoming increasingly popular amongst anesthesia providers. The growth in popularity of local anesthetic use is due to many factors pertaining to improved patient outcomes. In part, local anesthetics reduce or eliminate opioid use during surgery, which reduces unwanted side effects associated with opioids and can also provide extended analgesia in the post operative period (Patacsil, 2016). Uses of local anesthetics include intravenous (typically lidocaine), topical, spinal, epidural, peripheral or nerve plexus blocking, and direct injection into wound beds (Kremer & Griffis, 2018). The use of local or regional anesthesia techniques is associated with decreased perioperative pain and improved patient outcomes and satisfaction.

The administration of local anesthetics falls within the scope of practice for Certified Registered Nurse Anesthetists (CRNAs; American Association of Nurse Anesthetists [AANA], 2023). It is important for CRNAs to have knowledge about the effects, mechanism of action, pharmacokinetics, pharmacodynamics, and potential toxicity of local anesthetics. Local anesthetics prevent the transmission of pain signaling by acting on neurons as a reversible sodium channel blocker. Blocking sodium channels prevents nerve depolarization, which decreases action potential propagation to the brain (Tkach et al., 2023). While local anesthetics are beneficial when acting on the peripheral nervous system and spinal cord, they also have risks.

Local Anesthetic Systemic Toxicity (LAST) occurs most often due to the unintended injection of local anesthetics into circulation or rapid uptake from highly vascular areas. Once in circulation, local anesthetics can act on and negatively impact cardiac tissue, the brain, or both. LAST results in anaerobic metabolism in the central nervous system (CNS) and heart (Van

Wicklin, 2024). CNS symptoms can be as mild as perioral numbness, tinnitus, or dizziness and progress to confusion, dysphoria, and seizures. Cardiac symptoms of LAST can begin as hypotension and bradycardia, but can progress to more serious events such as arrhythmias, heart blocks, asystole, and ventricular fibrillation.

LAST is not a rare event. Though difficult to accurately quantify, the incidence of last is reportedly between 0.27 and 1.8 events per 1000 peripheral local anesthetics given (Tkach et al., 2023) and between 1.2 and 11 per 10,000 epidural anesthetics (Van Wicklin, 2024). The likelihood of LAST occurring is greatest when intravascular injection of local anesthetics occurs because LAST is due to increased plasma levels of local anesthetics. This is followed by intercostal, paracervical, caudal, epidural, brachial plexus, and sciatic administration, with subcutaneous administration being the least likely to result in LAST (Freeman & Berger, 2024).

Treatment of LAST is multifaceted. Early recognition of the above symptoms, followed by prompt treatment, is essential. The current standard of treatment includes airway management, seizure control with benzodiazepines or propofol, LAST specific Advanced Cardiac Life Support (ACLS) techniques, prompt administration of intralipids, and consideration of cardiopulmonary bypass (Van Wicklin, 2024). The main difference between ACLS techniques for LAST and standard cardiac arrest is the dosing of epinephrine. In standard ACLS, a one mg dose is used each time epinephrine is given. In LAST, the recommended dose is 0.1 mcg/kg. Some medications should also be avoided as they are ineffective or worsen outcomes associated with LAST. These include beta blockers, calcium channel blockers, and vasopressin. Prompt intralipid administration is currently the most important recommended treatment of LAST. Intralipids act as a “lipid sink” to absorb the local anesthetic agent in cardiac and brain

tissue and to redistribute it for metabolization and clearance (Nedialkov et al., 2018). Intralipids also act as an inotrope and improve cardiac function in the presence of LAST.

Checklists are associated with improved outcomes for patients as well as reduced variability between provider performance (Wiggins et al., 2018). As such, the implementation of a resource guide about LAST would be beneficial to an organization. The safe use of local anesthesia also helps to fulfill two of the four aspects of the Quadruple Aim: enhancing patient experience and reducing costs. Certain blocks allow for administering longer acting local anesthetics making it possible for patients to have very well-controlled pain for up to three days, greatly improving their healthcare experience. A quick reference guide for LAST would be an addition to the anesthesia department within the partnering organization.

The use of local and regional anesthesia is continuing to grow in popularity, and the AANA and the North Carolina Board of Nursing agree these techniques fall within CRNA scope of practice (AANA, 2023; North Carolina Board of Nursing, 2024). As such, CRNAs hold an important place in the prevention, identification, and treatment of negative events associated with local anesthetics and ensuring patient safety. This project is designed to create and implement a quick reference guide that will assist CRNAs in each of these tasks as well as improve their confidence regarding LAST.

Organizational Needs Statement

The partnering organization is an anesthesia department in a 974 bed medical center that completes about 100 surgical cases each day. As the use of local anesthetics as an adjunct or alternative for general anesthesia increases, the potential for the incidence of LAST cases in an organization also rises. At present, the partnering organization does not have a published resource or approved guide related to the prevention, identification, and management of LAST.

The partnering organization could benefit from a quick reference guide for LAST to assist anesthesia personnel in its prevention, diagnosis, and treatment as well as improving patient outcomes.

Problem Statement

Local Anesthetic Systemic Toxicity is an adverse effect of local anesthetic administration with an incidence between 0.27 and 1.8 per 1000 administrations that is costly to organizations and potentially fatal to patients (Tkach et al., 2023). In the partnering organization, CRNAs provide a significant amount of the care to patients receiving local anesthetics. At present, there is no published resource for CRNAs regarding LAST in the partnering organization.

Purpose Statement

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

Section II. Evidence

Description of Search Strategies

The search process for this project began with the creation of a PICOT (Problem Intervention, Comparison, Outcome, Time) question designed to both focus on the problem of LAST and facilitate search strategies. The PICOT question used to guide this search was "How is CRNA awareness, knowledge, and confidence in treating local anesthetic systemic toxicity impacted by implementation of a quick reference tool?" The main concepts used in the search were *CRNA, LAST, reference tool,* and *effectiveness* along with related terms discussed in Appendix A. Boolean operators, AND and OR, were used to combine the keywords and concepts into search strategies. Two databases were searched including PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the search engine Google Scholar.

In PubMed, 32 articles were found using the strategy "("Nurse Anesthetists" [Mesh] OR CRNA OR "Nurse Anesthetist" OR "Certified Registered Nurse Anesthetist") AND ("Local anesthetic systemic toxicity" OR LAST OR Local Anesthesia [Mesh])," five of which were retained for full text review. The limitations initially applied to the search were to be within the previous five years (2019-2024) and of English language. Too few results led to an increase in timeframe to the previous 10 years (2014-2024). Each of the 32 results were reviewed by title and abstract to determine relevance to the topic. Inclusion required a that the articles focused on Local Anesthetic Systemic Toxicity and held relevance to CRNAs. Five articles were then kept and read in full to determine the level of evidence, and strength of the articles. Two articles were then kept to inform the project

In CINAHL, 89 articles resulted using the search strategy "((MH "Certified Registered Nurse Anesthetists") OR CRNA OR "Nurse Anesthetist") AND ((MH "Anesthesia, Local") OR

"LAST" OR "Local anesthesia" OR "Local Anesthetic" OR "Systemic Toxicity") AND ((MH "Confidence") OR (MH "Knowledge") OR (MH "Self-awareness")),” 10 of which were retained. Similarly to PubMed, a five-year time frame did not provide sufficient results, so the limits applied to the search criteria were expanded to include peer reviewed articles of English language published between 2014 and 2024. After reviewing titles and abstracts for relevance, 10 articles were retained and read in full. Inclusion criteria was that the articles focused on Local Anesthetic Systemic Toxicity and held relevance to CRNAs. After full text review, three articles were retained to help support the project.

In Google Scholar, the search strategy used was “CRNA and “Local Anesthetic Systemic Toxicity” with the search limitations of published within the previous ten years (2014-2024) and in the English Language. This search resulted in 174 articles. After reviewing all 174 articles by title and Google relevance, 17 were retained for full text review. Inclusion criteria was that that the articles focused on Local Anesthetic Systemic Toxicity and held relevance to CRNAs. Two articles were kept after full text review to inform the project. Websites of professional organizations were also searched, but did not provide any articles for informing the project that the literature review did not also provide. The literature search log is detailed in Appendix B.

After full-text review, seven articles were deemed applicable to this project. The levels of evidence of these articles were reviewed using Melynk and Fineout Overholt’s (2019) hierarchy of evidence framework with Level I being the highest level of evidence and Level VII being the lowest level of evidence. Two randomized controlled trials (RCT, Level II), one case controlled cohort study (Level IV), two evidence based practice (EBP) or quality improvement (QI) projects (Level IV), and two literature reviews or expert opinions (Level VII) were identified as

supplying pertinent information to the project. See Appendix C for the literature matrix that was created to synthesize the above information regarding the sources.

Selected Literature Synthesis

The literature synthesized in this review is focused on current evidence regarding LAST, CRNA comprehension of LAST, associated complications, and educational tools regarding its prevention, identification, and treatment. The identified studies demonstrated that one of the most important issues associated with LAST is provider comprehension, specifically, of causes and treatment (El-Boghdadly et al., 2018; Ferguson et al., 2019; Neal et al., 2012; Tkach et al. 2023). A recent study conducted by Tkach et al. (2023) indicated that there is no correlation between the frequency of providers caring for patients receiving local anesthetics and their knowledge of LAST and its treatment. Exploring this correlation further, the researchers found knowledge scores of ASRA guidelines for LAST treatment of only 47.3%, yet 98% of participants recognized the importance of early lipid administration. This shows that though providers may routinely care for patients receiving local anesthetics, they may not be familiar with all of the ASRA guidelines for LAST treatment. It is also important to note that there was only a 6% (n=184/3000) response rate in this study. Providing a quick reference guide may help to address this issue and improve patient care. Ferguson et al. (2019) asserts that CRNAs are meant to be experts and key stakeholders regarding LAST events and included the importance of perioperative nursing personnel being comfortable with LAST. Anesthesia providers, in a study by Neal et al. (2012), reported that they should be able to recognize and treat LAST without the use of cognitive aids. Another study emphasized the importance of providers who administer local anesthetics being aware of their mechanisms of action, risk factors, prevention, and the

treatment of LAST events (El-Boghdadly et al., 2018). In summation, anesthesia provider comfort with and knowledge of prevention and treatment modalities of LAST is essential.

Of relevance to this project is the efficacy of cognitive aids in the recognition and treatment of LAST. The literature synthesis strongly indicates that using cognitive aids improves provider recognition, treatment, and confidence concerning LAST (Neal et al., 2012; Tkach et al., 2023; Watkins et al., 2022; Wiggins et al., 2018). Tkach et al. (2023) reported that participants who reported having immediate access to guidelines surrounding LAST scored significantly higher on their provider assessment than those without it. This led to the conclusion that "By providing cognitive aids such as posters, checklists, and emergency manuals in every operating room, CRNAs and other anesthesia providers will be better equipped to address LAST" (Tkach et al., 2023, p. 389). Similarly, Neal et al. (2012) demonstrated through a randomized controlled trial that when providers have access to a checklist, they perform significantly better on clinical tasks surrounding LAST, nearly doubling the score of the control group. In addition to improved scores, participants in the study stated that having a checklist improved their confidence and led to more rapid decision-making. Another study demonstrated that even after providing training about local anesthetic administration techniques and documented knowledge improvement, use of checklists remained beneficial (Wiggins, 2018). Lastly, Watkins et al. (2022) demonstrated that the use of digital decisional support tools improved providers' clinical judgement and application scores while simultaneously preserving non-technical skills such as provider communication. No evidence was identified which opposes the use of checklists or cognitive aids in the identification and treatment of LAST events.

Synthesis of literature explaining what LAST is, how to prevent and recognize it, and its treatment modalities was essential in the development of a quick reference guide for LAST. The

identified literature supports the assertion that LAST is a life-threatening multifactorial condition that impacts both the central nervous and cardiovascular systems (El-Boghdadly et al., 2018; Ferguson et al., 2019; Nedialkov et al., 2018). Attention to the prevention of LAST is essential when administering local anesthetics. Use of ultrasound guided local anesthetic administration techniques and the adherence to limits on dosing are two key preventative strategies (El-Boghdadly et al., 2018; Nedialkov et al., 2018). Strategies related to early recognition of LAST include: keeping patients on cardiac monitoring throughout and after administration of local anesthetics and frequently assessing their neurological status. Ferguson et al. (2019) raises concern that the anesthesia providers are not solely responsible for the recognition of LAST. Perioperative nursing staff are needed for monitoring and recognition. All identified literature agrees that the most important initial step once LAST is recognized is to stop local anesthetic administration and manage the patient's airway, breathing, and circulation. It is also essential to provide 100% oxygen and administer intralipid therapy (El-Boghdadly et al., 2018). Propofol should be avoided or used sparingly during seizures due to the potential for cardiac collapse, and benzodiazepines are the preferred seizure treatment. The American Society of Regional Anesthesia and Pain Medicine (ASRA) is identified as the leader in LAST treatment (Nedialkov et al., 2018). They developed a useful checklist for the treatment of LAST, the most recent rendition of which will be employed in this project as a part of the quick reference guide.

Current evidence supports the creation of an evidence based quick reference guide to support clinicians' confidence in preventing, recognizing, and treating LAST at the participating institution (Neal et al., 2012; Tkach et al., 2023; Watkins et al., 2022; Wiggins, 2018). This DNP project followed the information and recommendations in the literature in hopes to achieve this goal.

Project Framework

The framework applied to this project was the Institute for Healthcare Improvement (IHI, 2022) model for improvement as a single plan-do-study-act (PDSA) cycle. The four steps of this framework are useful in a quality improvement project as they allow for rapid assessment of short-term projects or single interventions. The initial step, *plan*, is meant to determine what to implement and how to do it, including gathering information about the problem and planning project tools to address it. The *do* step is to implement a project on a small scale and document the results. In The third step, *study*, the data is analyzed and compared to the predicted outcomes to reflect on the learned information. Lastly, the *act* step is meant for using the learned information and making changes to the intervention to plan for a continuation of the PDSA cycle.

The IHI PDSA cycle was useful for this project as it provided a way to test a small scale change. The *plan* phase included researching LAST, recognition, prevention, and treatment strategies, and creating a quick reference guide. The *do* phase included giving the CRNAs a laminated copy of the quick reference guide, a narrated PowerPoint presentation, as well as a pre-implementation survey. The CRNAs were then asked to utilize the quick reference guide for two weeks, and then take a post-implementation survey. The *study* phase included comparing the data collected in the two surveys and analyzing the results with the hope that the post-implementation survey would document the CRNAs perception of the adequacy of the quick reference guide for preventing and treating LAST. The last step, *act*, determined the necessary modifications to make to the quick reference guide and survey questions and suggest how it could be used on a larger scale.

Ethical Considerations and Protection of Human Subjects

No specific ethical concerns were identified related to this project as no more than minimal risk was assumed. The project tool consisted of the implementation of an educational quick reference guide and surveys to collect opinions of CRNAs perception of its usefulness. As LAST can cause patient harm, prolonged hospital stays, and increased costs for the institution, the benefit of implementing this tool was considered greater than the minimal risk that may have resulted from its implementation. The quick reference guide was distributed equitably across the target population of CRNAs working in the participating institution. No personal data was collected outside of email addresses. Participation in the study was voluntary and all data from the surveys was kept confidential.

Obtaining formal approval of the project included preparation including completing assigned Collaborative Institutional Training Initiative (CITI) modules (https://about.citiprogram.org/). Project preparation consisted of completing both the East Carolina University College of Nursing quality improvement screening tool, and the East Carolina University and Medical Center Institutional Review Board (UMCIRB) approval. These institutions deemed the project as quality improvement and thus exempt from full IRB review. Additionally, the project underwent an approval process through the participating institution and the UMCIRB, which required a document signed by a representative of the specific area of the participating institution where data was to be collected. This review also led to a determination of quality improvement that resulted in approval with no issues (See Appendix D).

Section III. Project Design

Project Setting

The project site was the main operating room department in a large Level 1 trauma center in the southeastern United States. This hospital houses 974 licensed beds and utilizes more than 50 operating rooms or procedural suites. The hospital specializes in several surgical subtypes, including pediatrics, obstetrics, cardiovascular services, orthopedics, plastics, urology, and general surgery. Factors serving as facilitators to the project included the frequency of local anesthetic use pre and post-surgery. Additionally, staff familiarity with setting up and assisting with local anesthetic blocks served as a positive aspect of project implementation. Potential barriers include low rates of participation by CRNAs due to production pressures, vacation schedules, and changing room assignments.

Project Population

The project population focused on CRNAs practicing at the project site. A major factor facilitating project implementation was the strong relationship between the university and anesthesia providers at the hospital. The anesthesia providers participating in the project mostly have prior involvement with university quality improvement projects as students or providers, which increases their familiarity with the participation process. The CRNAs' familiarity with local anesthesia processes served as a facilitator to project implementation.

Project Team

The team consisted of the author as team lead as well as three other student registered nurse anesthetists (SRNAs) as student team members. The student team initially collaborated on project development, but project implementation was performed separately and in different clinical settings. The team lead implemented this study in the main OR area of the participating

organization site and was responsible for data collection and analysis. The former nurse anesthesia program director acted as the supervising project chair. The current nurse anesthesia program director served as the clinical contact person. The partnering organization's clinical coordinator acted as the site contact person and signed the letter of acknowledgement for the data collection process. The course director who was a college of nursing faculty member assisted by guiding the team lead and offering direction through project development and implementation.

Methods and Measurement

The purpose of this DNP quality improvement project was to develop, implement, and evaluate the perceived usefulness of a quick reference guide designed specifically for anesthesia providers emphasizing LAST prevention, recognition, and treatment. The devised implementation consisted of an evidence-based quick reference guide and a narrated PowerPoint instructional presentation (Appendix E). Pre- and post-implementation surveys were created as a team and converted into Qualtrics surveys (Appendix F). The quick reference guide, PowerPoint presentation, and survey links were emailed to participants (Appendix G). Once participants completed the pre-implementation survey, the educational materials were to be reviewed. The quick reference guide was also provided as a hard copy to participants.

The IHI (2022) PDSA model guided the development and implementation of this DNP quality improvement project. An educational intervention consisting of a quick reference guide and narrated PowerPoint presentation with pre- and post-implementation Qualtrics surveys to guide and assess the project. The *plan* phase consisted of initial project development through collaboration between the entire SRNA team as well as the project chair, and the program director. Current evidence was analyzed for guidelines of best practice pertaining to LAST, and the project chair offered clinical expertise and guidance to create the project purpose, goals, and

Quick Reference Guide. The developed project was revised several times by the SRNA team members as well as the project chair and course director to secure confidence in efficiency and comprehension by participants. Project implementation approval was granted after applying for permission through the university and partnering organization's specific processes. Lastly, project participant recruitment was instituted by the site contact person by emailing CRNAs and creating a list of interested participants. Ten eligible project participants were recruited by decision of the site contact and clinical contact liaison.

The *do* phase consisted of first emailing the pre-implementation survey to the 10 eligible participants at the start of implementation. The educational materials were then emailed to the 10 participants and a hard copy laminated copy of the QRG was given to each of the 10 participants. Two weeks following the distribution of educational materials, the post-implementation survey was distributed via email to the 9 participants who had completed the pre-implementation survey and left open for two weeks to allow for completion. The 11-question pre-implementation survey and the 10 question post-implementation survey measured nominal, interval, and free response data. All responses to the surveys were kept confidential.

The *study* phase consisted of data analysis by the project lead comparing the pre-survey and post-implementation survey responses. The pre-implementation survey was completed by nine of the ten eligible project participants. The post-implementation survey was completed by nine of the original ten participants. Only the participants who completed the pre-implementation survey were able to complete the post-implementation survey as to not skew comparison of results. Data analysis consisted of both comparing pre-and post-implementation survey responses as well as participant subjective responses on open ended questions.

To conclude, the *act* phase consisted of presenting the outcomes to members of the organization and planning modifications to the quick reference guide and recommendations for future PDSA cycles. The implementation period would be extended to include enough time for the participating CRNAs to get used to using the QRG before evaluating its perceived usefulness. A new QRG would be created by the CRNAs at the organization such that it fit their specific needs. For example, if one or multiple of the local anesthetic agents listed is not used at the organization, it could be removed. Ultrasound guidance techniques could be added to the QRG as well. The implementation process would also have a project champion to encourage use of the QRG as well as involve members of the anesthesia care team outside of the participating CRNAs.

Section IV. Results and Findings

Results

The purpose of this quality improvement project was to develop a quick reference guide on LAST and assess the perception of its usefulness among CRNAs in an anesthesia department at a large medical center in eastern North Carolina. Pre- and post-implementation data were collected over a one-month period. The participants were sent an email inviting them to participate as well as the project materials. The project materials included the quick reference guide, narrated PowerPoint presentation on LAST, and the pre-implementation survey, which they were asked to complete within two weeks. Participants were then emailed the post-implementation survey and asked to complete it within two weeks. The data were collected using Qualtrics and analyzed using Microsoft Excel.

Ten CRNAs were initially invited to participate in the QI project. They were each sent the project materials as described above. During the two week implementation period, the 10 participants were sent a reminder email about the project. Of the ten initial participants, nine completed the pre-implementation survey and were sent the post-implementation survey. Upon completion of the post-implementation data collection period, all nine of the participating CRNAs completed the post-implementation survey.

Data Presentation

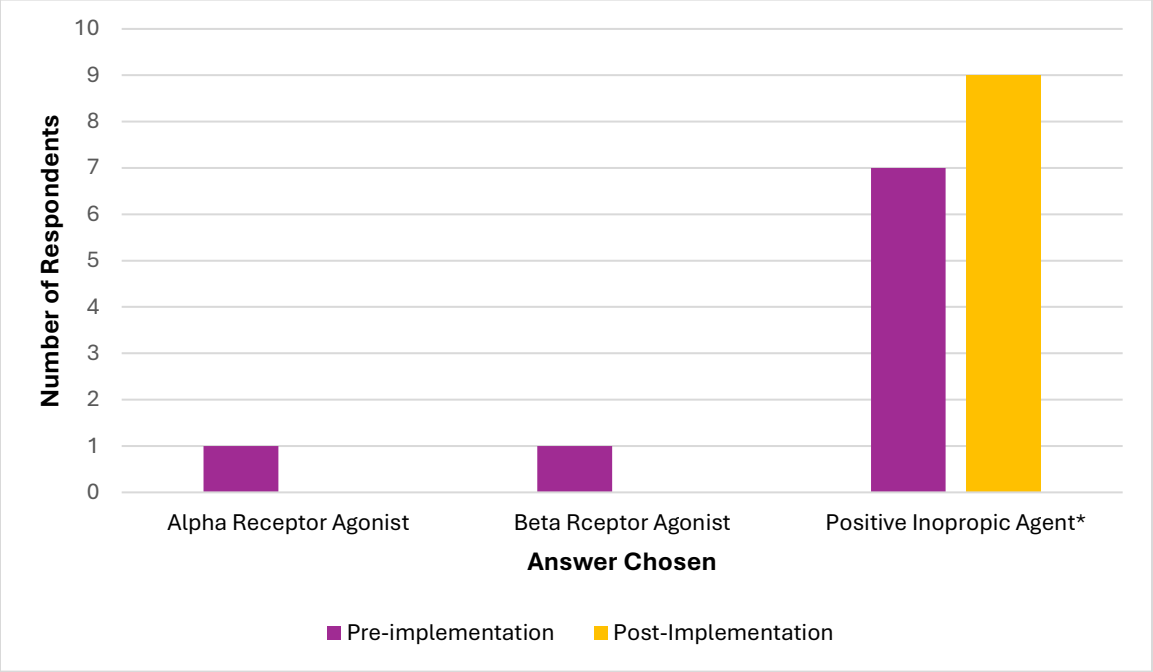
The pre-implementation survey assessed years of practice as a CRNA, use of local anesthetic agents, familiarity with LAST, familiarity with the BICEPSS mnemonic, and lipid emulsion therapy. When assessing experience levels of the CRNA participants, one selected *less than one year* of experience, three *1-4 years*, three *5-10 years*, and two *greater than 10 years*. Another question on the pre-implementation survey assessed how often the participants have

patients who receive local anesthetics in any form. Eight respondents identified that their patients receive local anesthesia *daily*, and one identified that their patients receive local anesthesia *weekly*. When assessing participant familiarity with LAST, none of the participants selected *not as all familiar* with LAST, one selected *somewhat familiar*, seven *moderately familiar,* and one *very familiar*. Another question in the pre-survey assessed participant confidence in identifying high risk populations for LAST. Again, none of the respondents selected *not at all confident*, two selected *somewhat confident*, six *moderately confident*, and one *very confident*. The pre-implementation survey also assessed participant confidence in dosing lipid emulsion therapy. None of the participants selected *not at all confident*, six *somewhat confident*, three *moderately confident,* and none selected *very confident*.

Several questions on the pre-and-post implementation surveys were intended to compare knowledge and confidence gained from the implementation materials. One pair of questions assessed the respondents' familiarity with the BICEPSS Mnemonic and its perceived usefulness. In the pre-implementation survey, six respondents selected *not at all familiar*, three *somewhat familiar*, and none selected *moderately or very familiar*. In the post-implementation survey, one respondent selected that the mnemonic was *not at all useful*, one *moderate usefulness*, and seven that the mnemonic was *very useful*. Another paired set of questions assessed participant knowledge of the mechanism of action of lipid emulsion therapy. In the pre-implementation survey, one respondent selected *alpha receptor agonist*, one chose *beta receptor agonist*, and seven correctly chose *positive inotropic agent*. None of the respondents chose *DNA synthesis inhibitor*. In the post-implementation survey, all nine participants correctly identified *positive inotropic agent* as the mechanism of action for lipid emulsion therapy. See Figure 1 for a visual comparison.

Figure 1

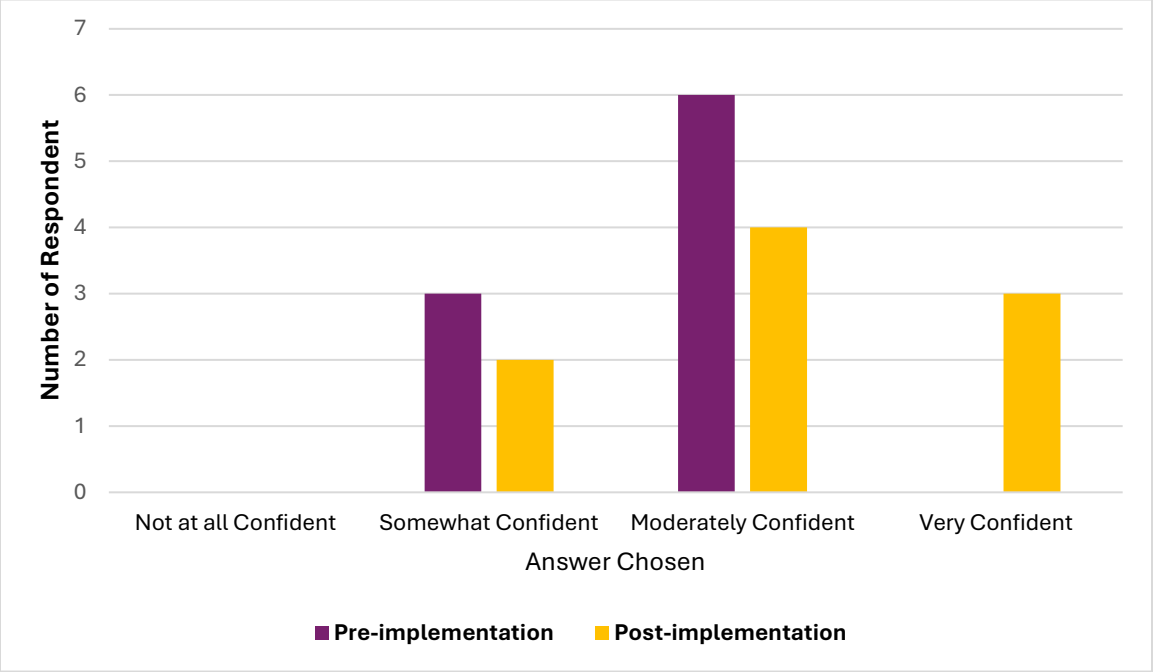
Pre and Post-implementation lipid emulsion therapy mechanism of action assessment (n=9)



Additionally, the pre-and post-implementation surveys compared participant confidence in their knowledge of maximum doses of local anesthetics before and after having access to implementation materials. In the pre-implementation survey, none of the participants selected that they were either *not at all confident*, or *very confident*, while three selected *somewhat confident* and six selected *moderately confident*. In the post-implementation survey, two selected *somewhat confident*, four selected *moderately confident,* and three selected *very confident* in their knowledge of maximum doses for local anesthetics. See figure 2 for a comparison of these confidence changes.

Figure 2

Pre and Post confidence in maximum dosage of local anesthetics with and without epinephrine (n=9)



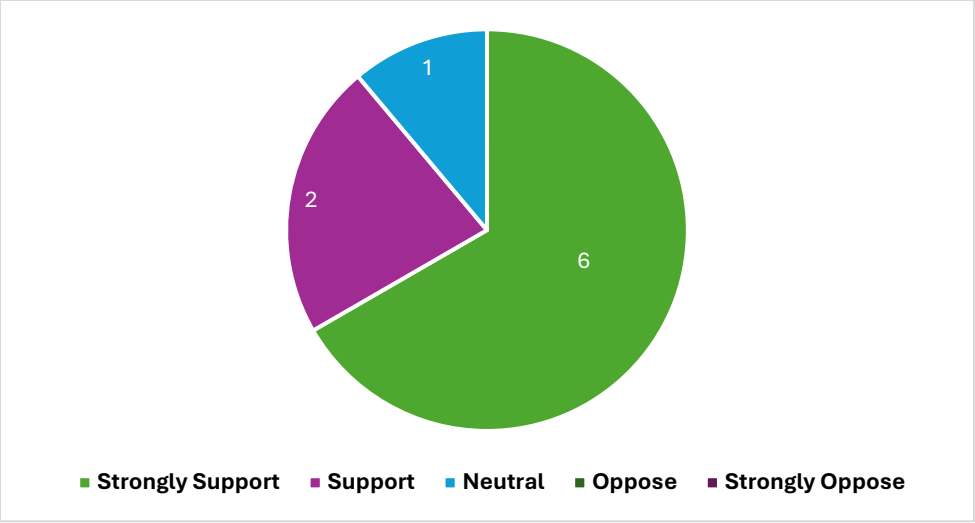
The last set of paired questions assessed participant familiarity with drugs to avoid in treating a patient with LAST. In the pre-implementation survey, none of the participants selected *not at all familiar*, eight *somewhat familiar*, one *moderately familiar* and none selected *very familiar*. In the post-implementation survey, three selected *somewhat familiar*, one *moderately familiar* and five *very familiar*. Again, none of the participants selected that they were *not at all familiar*.

The post-implementation survey also assessed data specific to the implementation period. This included the number of cases that utilized local anesthetics, number of times the participants identified patients at high risk for LAST, if the QRG improved LAST awareness, improved confidence in LAST treatment, and their support of the QRG. When assessing how many cases the respondents participated in that employed local anesthetics during the two-week

implementation period, one respondent reported that *no* cases used local anesthesia, four responded that *1-5*, three responded that *6-10*, and one responded that *more than 15*. The number of cases during the two-week implementation period that used local anesthesia and were identified as high risk for LAST included one respondent reporting that *0* cases were high risk, seven responded that *1-5* cases, one responded that *6-10*, and none of the respondents reported that they identified *more than 10* cases as high risk for LAST. When assessing if participants found that the QRG improved their awareness of LAST, eight reported that their awareness was improved, and one selected *no change*. Confidence in diagnosing and treating LAST during the implementation period included none of the respondents reporting *not at all confident*, two *somewhat confident*, two *moderately confident*, and five *very confident.* Lastly, the post-implementation survey addressed participant support for implementation of a LAST QRG at their facility. No respondents reported they were *opposed* to the QRG, one was *neutral*, two *supported*, and six *strongly supported* a QRG in their facility.

Figure 3

Post implementation support for implementing a LAST QRG at your facility (n=9)



Analysis

The sample of CRNAs at this facility had great diversity in years of experience as CRNAs but overall appear to have benefitted from the QRG provided in this QI project. At this facility, local anesthesia with regional block administration by CRNAs is limited. They aremainly administered by physician anesthesiologists. This lack of day-to-day administration may explain why in the pre-implementation period, some of the CRNAs responded as *somewhat* or *moderately confident* in their knowledge of local anesthetics, LAST, and lipid emulsion therapy instead of selecting *very confident*. However, none of the respondents reported *not at all confident* in these areas, indicating a strong background knowledge of LAST, possibly gained during their anesthesia training. One can speculate that years of experience and prior experience providing anesthesia at different facilities may have, in aggregate, improved the participants' confidence in these topics prior to the implementation period.

The questions that were included in both the pre-implementation and post-implementation surveys that were intended to assess the usefulness of the QRG demonstrated that the QRG had a positive impact on the CRNAs. Most participants selected *very useful* when asked about the BICEPSS mnemonic*,* indicating it is useful to determine what blocks are at the highest risk of causing LAST. The post-implementation survey also showed an improved knowledge of lipid emulsion therapy, as all nine respondents correctly identified its mechanism of action. Additionally, there was a positive shift in the data regarding confidence levels in both maximum doses of local anesthetics and drugs to avoid in the patient with LAST. This could be due to the QRGs emphasis on lipid emulsion therapy and maximum dosing of local anesthetics. The narrated PowerPoint also focused heavily on this material. The content of the QRG could

have positively influenced participant confidence levels if they accessed it while responding to the survey.

When asked to identify how many patients each CRNA had during the implementation period who received local anesthesia of any kind, fewer local anesthetics were given by each anesthetist than anticipated. This could be due to interpretation of the question as specifically local/regional anesthesia given by the CRNA. As stated, at the participating facility, the physician anesthesiologists administer the majority of the regional anesthesics. This could have influenced the respondent's perception of how often they are caring for patients who are receiving local or regional anesthesia. This also informs how often the CRNAs are assessing and identifying patients at high risk for LAST. When asked about identifying patients at high risk for LAST, all respondents selected that only *1-10* of their patients were at high risk. This could also have been situational as each CRNA is in different cases each day at this facility and may not be frequently assigned to patients receiving local anesthetics for their procedures, such as in orthopedics.

Despite low inciddnce of high-risk LAST cases, access to the QRG seems to have improved awareness of LAST among the participants as eight of nine respondents reported heightened awareness levels during the implementation period. Over half of respondents also selected that they were *very confident* in identifying and treating LAST with the remainder reporting *somewhat confident*. This is likely due in part to access to the QRG as indicated by the strong support of the QRG by the respondents. Support for the QRG was emphasized by one respondent who reported "The QRG is concise and very informative. Nice layout and easy to follow. Nice review of a topic we do not experience all that often" when asked how to improve

the QRG. Overall, the QRG and other implementation materials appear to have influenced participants positively despite potential barriers within the facility.

Section V. Implications

Financial and Nonfinancial Analysis

The expenses incurred by performing this QI project were minimal. The project lead printed and laminated ten copies of the QRG for distribution to project participants. This cost was approximately $30 (U.S.). The use of Qualtrics survey software was obtained through licensing with East Carolina University, the cost of which was included in the project lead's graduate student tuition. No costs were associated with IRB approval though the university.

The purpose of this DNP quality improvement project is to assess CRNA perceptions of adequacy of a LAST Quick Reference Guide designed to assist in identifying high-risk patients, to quickly diagnose LAST, and appropriately treat LAST should it occur. There was no financial cost or monetary benefit to the participating organization resulting from the implementation of this project. The participating organization may experience benefit from this project; however, due to the results of this project potentially influencing future QI projects within the institution and policy changes aimed at the prevention and treatment of LAST.

Additional QI projects or policy changes surrounding LAST could be quite beneficial to the participating organization. This QRG, or one developed by the organization, is a cost-effective and standardized method of LAST prevention and treatment. Placing laminated copies or a QR code on local anesthetic medication carts could potentially help providers prevent or sooner identify an occurrence of LAST. Orientation to the QRG should only take about 15 minutes. According to Kılıç et al. (2019), the first night in an ICU costs on average $3,678 and remains high throughout admission despite costs decreasing per day. The necessity of ventilation, or excess resuscitative measures such as ECMO can dramatically increase the cost. If

a QRG could prevent even one occurrence of LAST, the cost of the project could be entirely covered.

The potential costs of performing additional QI projects on LAST include development, acquisition, and dissemination of project materials. This cost includes paid employee hours for development and distribution as well as education regarding the tool, and cost of materials. Most of the participating CRNAs at this organization support the implementation of a QRG on LAST as it is not a condition that receives very much attention or continuing education. If these costs are compared to the cost of the most serious complication of LAST, including cardiovascular collapse, requirement of intensive care, and the potential need for ECMO, the potential financial benefit significantly outweighs the initial cost.

Implications of Project

Development and use of this project's QRG may help the partnering organization with aspects of the quadruple aim, namely enhancing patient experience and reducing costs (IHI, 2022). As the anesthesia care team model at the partnering institution is implemented such that CRNAs are not providing a majority of the regional anesthesia, this QRG provides a tool to enhance practice quality by CRNAs. The scope of practice for CRNAs includes the assessment, prescription, and administration of local anesthetics (AANA, 2023; North Carolina Board of Nursing, 2024).

The participating CRNAs found the QRG provided in this QI project to be useful, confidence boosting, and informative. Eight of nine supported implementing this QRG, or one similar to it, in the institution. This lends support to the need for a formalized reference on local anesthetics and LAST in the institution. A QRG would be a new resource CRNAs could use at their discretion that could potentially be a life and cost saving method. Support for the QRG is

grounded in evidence from current research that checklists and reference guides are beneficial to healthcare practitioners (Wiggins et al., 2018). One potentially more important implication for support of this project is that the CRNAs could modify or develop a new QRG that may better suit needs of the specific institution.

This QI project has implications for patient care and the healthcare system as a whole. Patients deserve providers who are confident in the care they are delivering. The improved confidence levels of the CRNAs may translate to improved patient care. Patient care improvement is often associated with reduced costs for patients, shorter hospital stays, and increased patient satisfaction. The institution could benefit from these patient care improvements by potentially seeing a higher number of patients who wish to receive elective surgical care through the institution. Lastly, CRNAs would no longer have to rely on memory to provide safe doses of local anesthetics and treatment protocols should LAST occur.

Sustainability

Sustainability for this project within the partnering institution is quite achievable. The costs incurred in this relatively small scale QI project were nearly negligible if applied to a major healthcare system such as the partnering institution. This makes reinvesting in this project and expanding it a reasonable task. The purpose of this DNP quality improvement project is to assess CRNA perceptions of adequacy of a LAST Quick Reference Guide designed to assist in identifying high-risk patients, to quickly diagnose LAST, and appropriately treat LAST should it occur. If this project were to be repeated by the partnering institution, it could be done on a larger scale, involving a larger group of CRNAs and could result in several plan-do-study-act cycles. This would ideally result in a comprehensive institution specific QRG on LAST that would be of

benefit to all CRNAs at the institution while also potentially helping peri-anesthesia nurses and other anesthesia providers.

One potential barrier to sustainability is the requirement of collaboration between a larger group of CRNAs at the institution to develop and assess newly developed or changed QRG(s). Differing schedules, priorities, and time constraints may make department collaboration difficult. Additionally, time spent working on this project may not be considered working time and may not include pay. This must be taken into consideration by both the institution and the participating CRNAs before undertaking this project. One additional barrier to future QI projects on LAST would be cultural changes. The current culture at this institution places the bulk of regional anesthesia administration on the physician anesthesiologists; however, CRNAs give local anesthesia and are responsible for caring for patients receiving regional every day. CRNAs might view future QI projects on LAST as an additional responsibility without a change in compensation. A potential solution to these barriers could be to place one staff member under assignment to sustain the project. This would allow one person to use paid time to prioritize this project and solicit help from fellow CRNAs.

Further QI projects aimed at establishing an institution specific QRG on LAST and local anesthetics for CRNAs may include examining current staff perceptions on the CRNA role in regional anesthesia. These projects might examine where CRNAs are most active in care surrounding local anesthetics. This might include emphasis on knowing the maximum dosages of the different local anesthetics and how they compound with each other. The most frequently used local anesthetics and ORs where local anesthetics are most often used could be observed. Extra focus on these local anesthetics and placement of QRGs in these specific rooms could also be

beneficial. Continuously revisiting this topic may lead to continued improvement in patient care, outcomes, and improve CRNA participation in regional anesthesia within this institution.

Dissemination Plan

The findings and observations of this project were presented to the nurse anesthesia department and program members, fellow SRNAs, university faculty, and the project chair through an oral and poster presentation. Those involved with participating in the project were invited to the presentation, but attendance was not required. The final rendition of the DNP quality improvement project paper and the poster presentation were uploaded to "The Scholarship," a university portal containing a digital library of academic works by university staff, faculty, and students that is available to the public.

Section VI. Conclusion

Limitations

Several factors limited the extent of this QI project. The first major limitation was the sample size. Only ten participants were selected in the initial participant group which created a limited data set. The data collection periods for both the pre- and post-implementation had to be extended to try an increase participation. In the initial two-week pre-implementation period, only five of the ten participants responded to the survey. After a reminder email was sent to the remaining participants, nine of the ten participants responded. One limitation in data collection for the pre-implementation survey was the Qualtrics survey system. The QRG was included at the end of the survey for download, but the participants had to return to the survey and advance to the next page to submit their responses. After troubleshooting this issue, most of the participants were able to submit their responses but one participant was not and thus was unable to participate in the post-implementation survey. If possible, future surveys using Qualtrics could be designed such that the project tools are available after submitting responses.

As stated previously, the CRNAs at the participating institution do not typically administer regional anesthetics. This may have created a limitation where the CRNAs felt less responsibility for preventing LAST. This may have influenced the CRNAs perceptions of the survey questions including the number of patients who received local anesthetics and were at high risk of LAST, and their desire to use the QRG.

Recommendations for Future Implementation and/or Additional Study

This QI project is considered the initial pilot study on development of a QRG for LAST prevention at the participating organization. The project lead had the opportunity to work with other SRNAs in a group to develop the QRG, the project surveys, and the project PowerPoint

presentation before independently implementing the project. This was intended to give the project lead experience and knowledge in each step of the PDSA cycle. Continuing this project through additional PDSA cycles would include the individualized development or editing of the QRG by CRNAs at the participating organization. Additional input could be made by including physician anesthesiologists at the participating institution. A larger sample size and longer implementation period may also elicit more robust results as well as raise the awareness level of the QRG within the anesthesia department. Another beneficial strategy would be to familiarize peri-anesthesia nurses, who frequently assist with regional blocks, to the QRG in order to strengthen safeguards against LAST.

This project focused more on the treatment of LAST. Future projects could place additional emphasis of the prevention of LAST. This could include techniques for administration of local anesthetics using ultrasound guidance, emphasis of periodic aspiration during administration to prevent intravascular injection, and typical volumes of local anesthetics for different peripheral nerve blocks. Future projects could also consider placement of the QRG on each ‘block cart’ used at the facility as well as distribution to the participating providers in the project. This could raise awareness of the project and be beneficial to those providers who are not directly associated with the project. One last recommendation for future QI projects on this topic would be to include a project champion. The project lead acted as a project champion in this project and actively championing the project greatly improved participation.

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Appendix A

Literature concepts table

	Certified Registered Nurse Anesthetist	Local anesthetic systemic toxicity	Reference tool	Effectiveness
Keywords	CRNA Nurse Anesthetist	LAST Local anesthesia Local anesthetic Systemic toxicity	Tip sheet Reference guide Reference tool Resource	Impact Confidence Knowledge Awareness
PubMed MeSH	“Nurse Anesthetist” [MeSH Terms]	“Local Anesthesia” [MeSH Terms) “Local Anesthetics” [MeSH Terms]		“Self Concept” [MeSH] “Awareness” [MeSH]
CINAHL Subject headings	(MH “Certified Registered Nurse Anesthetists”)	(MH "Anesthesia, Local")	(MH "Reference Tools")	(MH "Confidence") (MH "Knowledge") OR (MH "Nursing Knowledge") OR (MH "Professional Knowledge") (MH "Self-Awareness") (MH "Clinical Effectiveness") OR (MH "Treatment Outcomes")

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
09/12/2024	PubMed	("Nurse Anesthetists" [Mesh] OR CRNA OR "Nurse Anesthetist" OR "Certified Registered Nurse Anesthetist") AND ("Local anesthetic systemic toxicity" OR LAST OR Local Anesthesia [Mesh]) (("Nurse Anesthetists"[MeSH Terms] OR ("crna"[Journal] OR "crna"[All Fields]) OR "Nurse Anesthetist"[All Fields] OR "Certified Registered Nurse Anesthetist"[All Fields]) AND ("Local anesthetic systemic toxicity"[All Fields] OR "LAST"[All Fields] OR "anesthesia, local"[MeSH Terms])) AND (2014:2024[pdat])	10 Years (2014-2024) English Language Peer-Reviewed	5/32	Inclusion: Must include anesthesia care and information related to local anesthesia techniques/outcomes Exclusion: focus on outcomes unrelated to local anesthetic systemic toxicity even when local anesthetics were used, and irrelevance
09/12/2024	CINAHL	((MH "Certified Registered Nurse Anesthetists") OR CRNA OR "Nurse Anesthetist" OR "Nurse Anesthesia") AND ((MH "Anesthesia, Local") OR "LAST" OR "Local anesthesia" OR "Local Anesthetic" OR "Systemic Toxicity") AND "toxicity"	10 Years (2014-2024) English Language Peer-Reviewed	10/89	Inclusion: Local/neuraxial anesthesia, Anesthesia care, Systemic toxicity Exclusion: Local anesthesia research without a focus on outcomes or toxicity
09/12/2024	Google Scholar	CRNA and “Local Anesthetic Systemic Toxicity”	10years (2014-2024)	17/174 All 18 pages reviewed	Inclusion: Anesthesia care and local anesthesia. Must discuss LAST. Can discuss LAST prevention strategies

			English Language	for title and google relevance	Exclusion: mentions LAST but does not discuss it/emphasize it

Appendix C

Literature matrix

Year	Author, Title, Journal	Purpose & Conceptual Framework or Model	Design and Level of Evidence	Setting	Sample	Tool/s and/or Interventions/s	Results
2023	Tkach, L., Baillie, L., Newby, J., O'Guin, C., Bowman Dalley, C., Crowell, N., & Eshkevari, L. (2023). Assessing CRNA Knowledge of Local Anesthetic Systemic Toxicity Treatment. *AANA Journal*, *91*(5), 385–390.	To assess CRNA knowledge of the 2020 American Society of Regional Anesthesia and Pain Medicine (ASRA) LAST treatment guidelines To determine whether there was a relationship between the frequency of CRNAs' exposure to perioperative local anesthetic use and their knowledge level No conceptual framework or model noted	Level IV: case-controlled cohort study	Online survey of AANA members	184 AANA members who responded to the online survey out of 3,000 surveys sent	De novo data collection tool to assess CRNA knowledge of LAST that was approved by five experts Analysis of demographic data and average knowledge scores Spearman's correlation assessment between knowledge scores and frequency of exposure to local anesthetic use T-test to identify relationship between knowledge	The average score on the assessment was 47.3% There was no correlation between frequency of caring for a patient receiving local anesthetics and knowledge or LAST or its treatment Participants with immediate access to written or electronic guidelines had significantly higher scores on the assessment than those who did not "By providing cognitive aids such as posters, checklists, and emergency manuals in every operating

						scores and immediate access to LAST guidelines	room, CRNAs and other anesthesia providers will be better equipped to address LAST"
2022	Watkins, S. C., de Oliveira Filho, Getulio R., Furse, C. M., Muffly, M. K., Ramamurthi, R. J., Redding, A. T., Maass, B., & McEvoy, M. D. (2022). The effect of novel decision support tools on technical and non-technical performance of teams in managing emergencies. *Journal of Medical Systems, 46*(11), 75-75. https://doi.org/10.1007/s10916-022-01866-4	"To explore the effects of different decision support tools, a type of cognitive aid, on the technical and non-technical performance of teams" To assess the difference between non-technical, technical, and combined decision support tools No conceptual framework noted	Level II: Randomized controlled trial	Simulated scenarios involving Peri-operative personnel approved by Vanderbilt University IRB.	35 peri-operative teams including an anesthesia provider, OR nurse and PACU nurse.	Three decision support tools, one technical, one non-technical and one combined were created to assist with pediatric simulated peri-operative emergencies A technical skill checklist to measure technical skills the Team Emergency Assessment Measure (TEAM) and a Behavior Anchored Rating Scale (BARS) to test for non-	The technical and combined decisional support tools had a significant impact on improving scores in the technical category. The non-technical decisional support tool created worse technical outcomes. None of the tools had an impact on non-technical scores compared to not using a tool in general. Though this trial employed a digitized interactive format the tool, the information supports the creation of our tool by showing the benefit of a mixed

						technical skills	technical and non-technical support tool/guide
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	"To improve knowledge and raise awareness of nurses who assist certified registered nurse anesthetists or anesthesiologists with peripheral nerve block or spinal block procedures about a potential life-threatening local anesthetic systemic toxicity (LAST) event." No conceptual framework noted	Level VI: EBP/QI	Hospital: PACU, outpatient services, labor and delivery unit	70 RNs who worked in peri-anesthesia areas of a level II trauma center in northern Idaho	A 10 question pre and post-test developed to assess the nurse's knowledge of LAST 30-minute training session that was developed to teach what LAST is, its symptoms and treatment	A lot of literature review data and information on what LAST is and its treatment. Identifies importance of perioperative nurse comfort with LAST Identifies CRNAs as key stakeholders and experts on LAST
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	To define LAST mechanisms, pharmacokinetics, presentation, risk factors, prevention, and management. No conceptual framework noted	Level VII: expert opinion and literature review	N/A	N/A	N/A	"LAST is a life-threatening adverse event, and recent advances in understanding the pathophysiological basis of the condition and its therapy will improve patient safety. It is imperative that

	.org/10.2147/LRA.S154512						practitioners who use LA in their clinical practice are cognizant of the mechanisms, risk factors, prevention, and therapeutic modalities." This article has very detailed and comprehensive information of the pathophysiology and treatment of LAST that will contribute greatly to the quick reference guide/tool
2018	Wiggins, L. L. (2018). Using Evidence-Based Best Practices of Simulation, Checklists, Deliberate Practice, and Debriefing to Develop and Improve a Regional Anesthesia Training Course. *AANA Journal*, *86*(2), 119–126.	"To determine the effectiveness of a blended-learning regional anesthesia training curriculum on improving CRNA knowledge, skill, and attitude in regional anesthesia administration as part of a clinical credentialing pathway"	Level VI: QI	Peter M. Winter Institute for Simulation, Education, and Research (WISER), located in Pittsburgh, Pennsylvania	49 CRNAs; average experience of 15.5 years. Participants must have completed at least 50 spinal or epidural blocks in the previous year	Checklists were developed based on previously published anesthesia checklists and modified to ensure validity. These checklists focused sterile technique and spinal/epidural block placements	This article demonstrates the utility of checklists both as a method of training and as a method of improved outcomes This article also discusses how in some institutions, CRNAs are not acting to their full scope of practice by not placing spinal/epidural blocks and how

		No conceptual framework noted		A single large academic healthcare system that enrolled in NARAT course		Pre-course demographic and experience survey 15-minute video providing step by step instructions for each procedure Blended curriculum for spinal and epidural training with didactics, checklists and experiential learning Post course survey rating the value of the course as a credentialing program and comfort/confidence levels of the participants	checklists/resources/credentialing programs could improve this
2018	Nedialkov, A. M., Umadhay, T., Valdes, J. A., & Campbell, Y. (2018).	To synthesize the literature surrounding the use of intravenous fat	Level VII: Literature review	N/A	25 articles surrounding intralipid therapy for LAST	CINAHL, Medline, Scopus, PubMed, and google	This article has an abundance of information surrounding the use of

	Intravenous fat emulsion for treatment of local anesthetic systemic toxicity: Best practice and review of the literature. *AA NA Journal, 86*(4), 290-297.	emulsion as treatment for LAST No conceptual framework noted				scholar were used to collect articles using search terms: lipid emulsion, local anesthesia toxicity, resuscitation, lipid rescue, intravenous fat emulsion, lipid sink and intralipid therapy	intralipids to treat LAST – backs up information used in the tool surrounding importance of prompt intralipid administration when warning signs are noted
2012	Neal, J. M., Hsiung, R. L., Mulroy, M. F., Halpern, B. B., Dragnich, A. D., & Slee, A. E. (2012). ASRA checklist improves trainee performance during a simulated episode of local anesthetic systemic toxicity. *Regional Anesthesia and Pain Medicine, 37*(1), 8-	To determine the effectiveness of the ASRA LAST checklist designed in 2010 in treating a simulated episode of LAST To determine the checklists usability and readability	Level II: Randomized controlled trial	Virginia Mason Medical Center	25 participants with 12 in the checklist group and 13 in the non-checklist group Participants were 1st, 2nd and 3rd year anesthesia residents, clinical anesthesia personnel, and regional anesthesiology/acute pain fellows	Scripted and programmed simulation using SimMan ASRA practice advisory executive summary and ASRA LAST checklist Anesthesiologists' non-technical skill tool and a performance	The checklist group significantly outperformed the no checklist group with 16 correctly performed tasks on average compared to 8.8 in the non-checklist group Administration of lipid emulsion correctly was significantly higher in the checklist groups Subjects reported that

	15. https://doi.org/10.1097/AAP.0b013e31823d825a					evaluation tool based on the ASRA checklist	they should be able to do these tasks without a checklist but that they did not feel bad using it Subjects stated that the checklist made more rapid and confident decision making possible

Appendix D

Approval Forms

CON Screening: Background Information

(LAST)

The purpose of this quality improvement project is to assess anesthesia providers' perceptions of the adequacy of a newly developed quick reference guide for Local Anesthetic Systemic Toxicity (LAST).

Process: A perioperative quick-reference guide (QRG), based upon accepted national guidelines, will be developed. Anesthesia providers at [redacted] will be asked several questions (through Qualtrics) about their perceptions of adequacy of their currently used processes within their practice. An educational video about the use of the newly developed QRG for LAST will be made available to them. They will be asked about the use of the QRG for two weeks. Upon completion of the two-week utilization period, they will be asked to complete a questionnaire about their perceptions of the adequacy of the QRG for preventing and treating LAST in their current practice setting. Qualtrics survey software will be used to deliver the intervention link and gather participant perceptions prior to and post-implementation of the project. No patient information will be recorded or maintained during the project.

Question 1: Will the project involve testing an experimental drug, device (including medical software or assays), or biologic (i.e., vaccines, blood products, gene therapy, tissues)?

No

Question 2: Has the project received funding (e.g., federal, industry) to be conducted as a human subject research study?

No

Question 3: Is this a multi-site project (e.g., there is a coordinating or lead center, more than one site participating, and/or a study-wide protocol)?

No

Question 4: Is this a systematic investigation designed with the intent to contribute to the generalizable knowledge (e.g., testing a hypothesis; randomization of subjects; comparison of case vs. control; observational research; comparative effectiveness research; or comparable criteria in alternative research paradigms)?

No

Question 5: Will the results of the project be published, presented or disseminated outside of the institution or program conducting it?

No

Question 6: Would the project occur regardless of individuals conducting it may benefit professionally from it?

Yes

Question 7: Does the project involve “no more than minimal risk” procedures (meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests)?

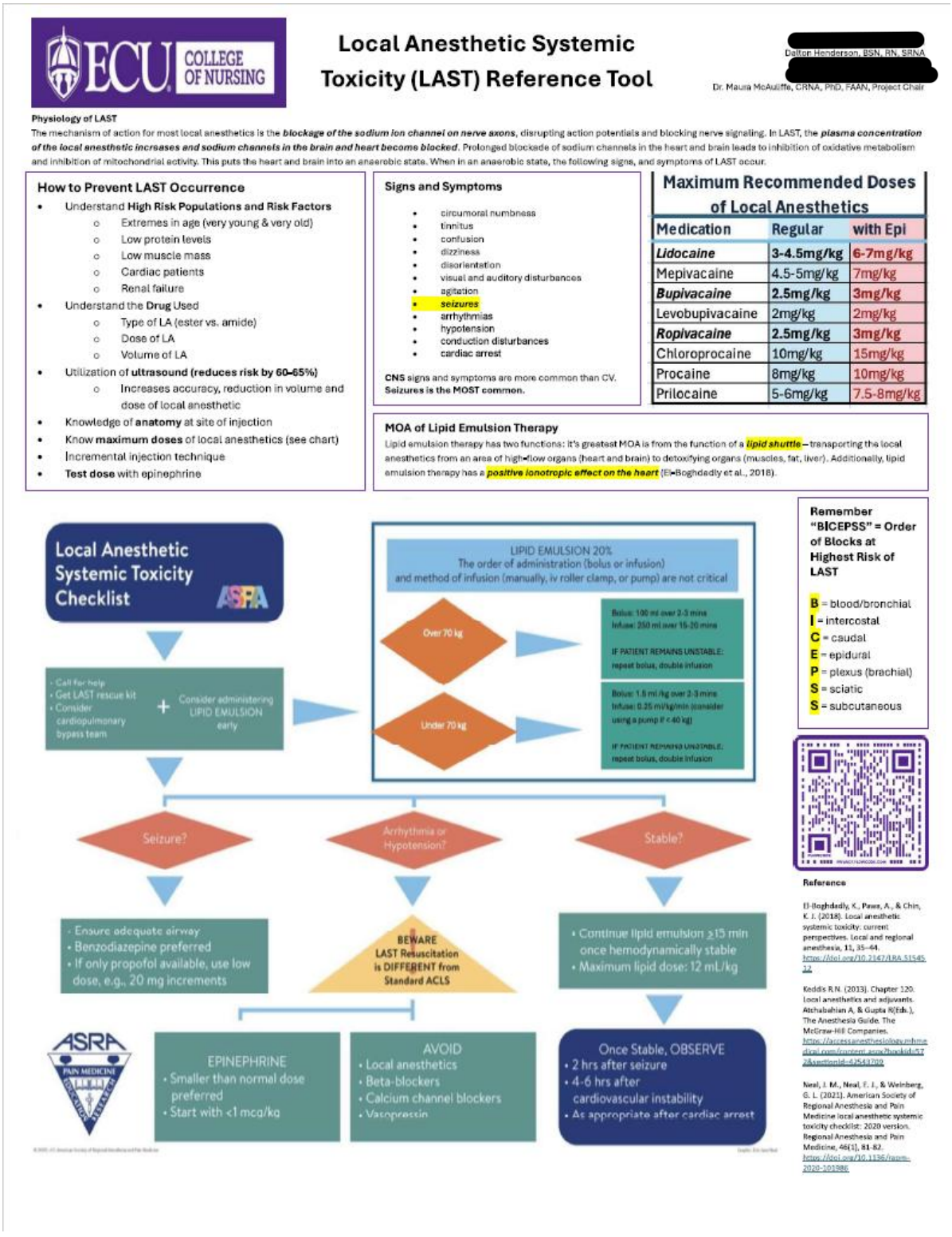
No

Question 8: Is the project intended to improve or evaluate the practice or process within a particular institution or a specific program, and falls under well-accepted care practice/guidelines?

Yes

Appendix E

Quick Reference Guide and PowerPoint



ECU COLLEGE OF NURSING

Local Anesthetic Systemic Toxicity (LAST) Reference Tool

[redacted]
Dalton Henderson, BSN, RN, SRNA
[redacted]
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).

Local Anesthetic Systemic Toxicity Checklist ASRA

- Call for help
- Get LAST rescue kit
- Consider cardiopulmonary bypass team

+ Consider administering LIPID EMULSION early

LIPID EMULSION 20%
The order of administration (bolus or infusion) and method of infusion (manually, iv roller clamp, or pump) are not critical

Over 70 kg
Bolus: 100 ml over 2-3 mins
Infuse: 250 ml over 15-20 mins
IF PATIENT REMAINS UNSTABLE: repeat bolus, double infusion

Under 70 kg
Bolus: 1.5 ml/kg over 2-3 mins
Infuse: 0.25 ml/kg/min (consider using a pump if < 40 kg)
IF PATIENT REMAINS UNSTABLE: repeat bolus, double infusion

Seizure?
- Ensure adequate airway
- Benzodiazepine preferred
- If only propofol available, use low dose, e.g., 20 mg increments

Arrhythmia or Hypotension?
BEWARE LAST Resuscitation is DIFFERENT from Standard ACLS

EPINEPHRINE
- Smaller than normal dose preferred
- Start with <1 mcg/kg

AVOID
- Local anesthetics
- Beta-blockers
- Calcium channel blockers
- Vasopressin

Stable?
- Continue lipid emulsion ≥15 min once hemodynamically stable
- Maximum lipid dose: 12 mL/kg

Once Stable, OBSERVE
- 2 hrs after seizure
- 4-6 hrs after cardiovascular instability
- As appropriate after cardiac arrest

ASRA PAIN MEDICINE

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

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

Reference

El-Boghdadly, K., Pawa, A., & Chin, K. J. (2018). Local anesthetic systemic toxicity: current perspectives. Local and regional anesthesia, 11, 35–44. https://doi.org/10.2147/LRA.S154532

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

Neal, J. M., Neal, F. 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

A Quick Reference Guide (QRG) to Local Anesthetic Systemic Toxicity (LAST)

Courtney Dilao, SRNA
Dalton Henderson, SRNA
Mary Elise Pierce, SRNA
Cordelia Rios, SRNA

In partial fulfillment of a DNP Project

ECU

Objectives

- 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
- Learn how to implement the Quick Reference Guide (QRG)

- Important points are **bolded**

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Review of Local Anesthetics

- Mechanism of Action of Local Anesthetics
  - **Sodium channel blockers**
  - Reversible binding to voltage-gated sodium channels
- **Weak Bases**
- Lipophilic aromatic ring connected through either an ester or amide link to a hydrophilic tertiary amine
  - Ester or amide link determine classification of local anesthetic

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Review of LAST

- 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
- Signs and Symptoms
  - Early: circumoral numbness, tinnitus, vision and mental status changes
  - Anesthetized patient: EKG changes, hemodynamic instability such as arrhythmias, conduction disturbances, and hypotension
  - Late: **seizures** and cardiac arrest

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Risk Factors

- Several patient specific factors increase the risk of LAST
  - extremes in age (the very young and very old)
  - low protein levels
  - cardiac pathology
  - renal failure
  - low muscle mass
- Type of local anesthetic used
- Dose and volume

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Location, Location, Location

- Use **"BICPESS" mnemonic** to remember the order of blocks with ***greatest risk*** of LAST
  - B = blood/bronchial (direct IV injection)
  - I = intercostal blocks
  - C = caudal blocks
  - E = epidural
  - P = plexus (brachial)
  - S = sciatic
  - S = subcutaneous

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Prevention of LAST

- Understand **high risk populations and risk factors**
- Understand pharmacokinetics and pharmacodynamics of local anesthetics
- **Know maximum dosages of drugs**
- **Utilization of ultrasound**
- Knowledge of anatomy at injection site
- **Incremental injection technique with frequent aspiration**
- Test dose with epinephrine

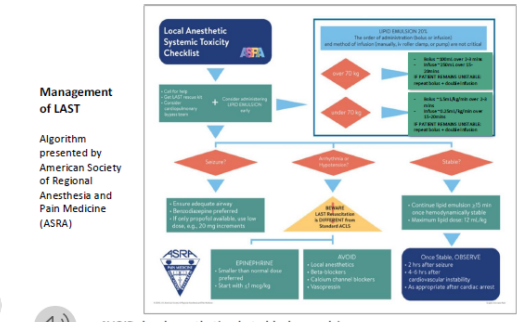
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Importance of QRG for LAST

- Anesthesia providers are directly responsible for administration of and safety regarding local anesthetics
- Up to 1.8 events per 1,000 peripheral local anesthetics given results in LAST
- Up to 1.1 events per 1,000 epidurals given results in LAST
- The treatment of cardiac arrest in a patient with **LAST differs from standard ACLS protocols**
  - **< 1 mcg/kg epinephrine as initial dosing in LAST vs standard 1 mg dose in ACLS**

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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



Treatment

- **Lipid emulsion therapy (LET)**
  - > 70kg
    - Bolus 100mL over 2-3 mins
    - Infuse 250mL over 15-20mins
      - If patient remains unstable: repeat bolus + double infusion
  - < 70kg
    - Bolus 1.5mL/kg over 2-3 mins
    - Infuse 0.25mL/kg/min
      - If patient remains unstable: repeat bolus + double infusion

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Intralipid Pharmacology

- **Lipid shuttle**
  - Transporting anesthetic from heart and brain to muscle, fat, and liver
- **Positive inotropy**

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How to use the Quick Reference Guide (QRG)

- To have a quick and easy resource accessible from your phone or available in the OR
- To help identify patient and procedure risk factors
- 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

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Appendix F

Pre & Post Implementation Surveys

LAST Pre-survey

Start of Block: Pre-Implementation Surveys

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

- ○ Less than 1 year (1)
- ○ 1-4 years (2)
- ○ 5-10 years (3)
- ○ Greater than 10 years (4)

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

- ○ Daily (1)
- ○ Monthly (2)
- ○ Weekly (3)
- ○ Rarely (4)

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

- ○ Not familiar at all (1)
- ○ Somewhat familiar (2)
- ○ Moderately familiar (3)
- ○ Very familiar (4)

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

- ○ Not at all confident (1)
- ○ Somewhat confident (2)
- ○ Moderately confident (3)

- ○ Very confident (4)

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

- ○ Not at all confident (1)
- ○ Somewhat confident (2)
- ○ Moderately confident (3)
- ○ Very confident (4)

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

- ○ Not familiar at all (1)
- ○ Somewhat familiar (2)
- ○ Moderately familiar (3)
- ○ Very familiar (4)

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

- ○ Alpha receptor agonist (1)
- ○ Beta receptor agonist (2)
- ○ Positive inotropic agent (3)
- ○ DNA synthesis inhibitor (4)

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

- ○ Not at all confident (1)
- ○ Somewhat confident (2)

- ○ Moderately confident (3)
- ○ Very confident (4)

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

- ○ Not familiar at all (1)
- ○ Somewhat familiar (2)
- ○ Moderately familiar (3)
- ○ Very familiar (4)

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?

- ○ Not at all confident (1)
- ○ Somewhat confident (2)
- ○ Moderately confident (3)
- ○ Very confident (4)

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

- ○ Not familiar at all (1)
- ○ Somewhat familiar (2)
- ○ Moderately familiar (3)
- ○ Very familiar (4)

End of Block: Pre-Implementation Survey

Start of Block: LAST QRG

Q Please review the QRG here Final last tool

End of Block: LAST QRG

Start of Block: Post-Implementation Survey

LAST Post-survey

Start of Block: Default Question Block

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?

- ○ 0 (1)
- ○ 1-5 (2)
- ○ 6-10 (3)
- ○ 11-15 (4)
- ○ >15 (5)

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?

- ○ 0 (1)
- ○ 1-5 (2)
- ○ 6-10 (3)
- ○ 11-15 (4)
- ○ >15 (5)

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?

- ○ Not at all useful (1)
- ○ Somewhat useful (2)
- ○ Moderately useful (3)
- ○ Very useful (4)

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

- ○ Alpha receptor agonist (1)
- ○ Beta receptor agonist (2)
- ○ Positive inotropic agent (3)
- ○ DNA synthesis inhibitor (4)

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?

- ○ Not at all confident (1)
- ○ Somewhat confident (2)
- ○ Moderately confident (3)
- ○ Very confident (4)

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

- ○ Not familiar at all (1)
- ○ Somewhat familiar (2)
- ○ Moderately familiar (3)
- ○ Very familiar (4)

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

- ○ Yes (1)
- ○ No (2)
- ○ No change (3)

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

- ○ Not at all confident (1)
- ○ Somewhat confident (2)
- ○ Moderately confident (3)
- ○ Very confident (4)

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

- ○ Strongly oppose (1)
- ○ Oppose (2)
- ○ Neural (3)
- ○ Support (4)
- ○ Strongly support (5)

Q10 Do you have any recommendations to improve this QRG?

_____

_____

_____

_____

_____

End of Block: Default Question Block

Appendix G

Emails to Participants

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

Dear [redacted] CRNAs,

Thank you for considering participating in a quality improvement project titled "Local Anesthetic Systemic Toxicity Prevention Recognition and Treatment in a Perioperative Setting: A Quality Improvement Project and DNP Project." The purpose of this project is to assess the perceived usefulness of a quick reference guide (QRG) regarding local anesthetic systemic toxicity (LAST) in the [redacted] main operating room setting.

Participation is voluntary and will involve completing a short pre-intervention survey, viewing a brief narrated PowerPoint presentation, utilizing the 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 five minutes to complete and the PowerPoint should take roughly 10 minutes to read and listen to. The surveys were created and are completed using Qualtrics® survey software. The use of the 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-intervention survey provide link here.

Following completion of the survey, view the attached PowerPoint on LAST and the QRG. Printed and Laminated copies of the QRG will be available upon request and are available in my mailbox in the anesthesia work room within the main OR

Again, thank you for your participation in our quality improvement project. I will be [redacted] main OR from 4/15/2025-4/26/2025 if you have any questions, you may also reach out to me or Dr. Maura McAuliffe by email at any time.

Sincerely,

Dalton Henderson, SRNA Hendersond16@students.ecu.edu
Maura McAuliffe *PhD, CRNA, FAAN,* Project Chair

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

Hello [redacted] CRNAs,

I just wanted to send a quick reminder about the ongoing DNP Project on local anesthetic systemic toxicity (original email below). If you've already filled out the pre-survey and viewed the PowerPoint, 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 quick reference guides in my mailbox if you haven't already received one. You may use these at your discretion. After the end of next week, I will begin sending out the post-surveys.

Links:
Pre-survey
PowerPoint

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

Sincerely,
Dalton Henderson, SRNA
ECU Nurse Anesthesia Program
Class of 2026

Post-Survey Email to Participants (3)

Dear [redacted] CRNAs,

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

If you have not filled out a pre-survey, I would really and truly appreciate your participation (it's just surveys and a PowerPoint!). The link to the pre-survey is __link__, and you can follow it up by watching the introductory PPT attached below. Quick reference guides 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 at link to the post-survey. It should take less than 5 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 continuing to work with you all in the various operating suites at [redacted].

Sincerely,
Dalton Henderson, SRNA
ECU Nurse Anesthesia Program

Class of 2026
Final Thank You Email to Participants (4)

Dear [redacted] CRNAs,

I just wanted to say thank you so much to everyone for helping me out with my DNP Project! I have collected all of the data I need to proceed with data analysis and will then be finishing my paper. Once it's complete you all will be able to read it if you'd like. And if you liked the quick reference guide and found it useful, you can continue to use them at your discretion. If you ever need another copy, feel free to reach out and I can send you one digitally.

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

Take care,
Dalton Henderson, SRNA
ECU Nurse Anesthesia Program
Class of 2026