# IMPROVING AWARENESS AND KNOWLEDGE OF LOCAL ANESTHETIC SYSTEMIC TOXICITY AMONGST LABOR AND DELIVERY NURSES: THROUGH EDUCATION, SIMULATION, AND COGNITIVE AIDS

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## ABSTRACT

**Background:** Local Anesthetic Systemic Toxicity (LAST) is a high-acuity, low-occurrence medical emergency caused by increased plasma concentrations of local anesthetics. When early signs and symptoms such as tinnitus, confusion, and tingling around the mouth go unidentified, symptoms can quickly progress to respiratory and cardiac arrest. Although LAST events are infrequent, they contribute to maternal morbidity and mortality. **Purpose:** This project aimed to provide traditional education and simulation to increase awareness, knowledge, and confidence in recognizing LAST and providing prompt treatment to laboring mothers. **Methods:** Labor and delivery nurses received a PowerPoint presentation and a scripted LAST simulation. The project used a mixed-method cross-sectional design to collect data to evaluate awareness, knowledge, and confidence following the implementation. **Results:** Thirty-two labor and delivery nurses participated in the implementation of this project, and fourteen of the thirty-two participants participated in the one-month follow-up surveys. Data collected by the pre-and post-surveys were analyzed using paired t-tests for two samples. All participants had increased awareness and knowledge of LAST, and most had increased confidence after the intervention. **Conclusion:** Results indicated that the intervention effectively increased awareness, knowledge, and confidence in identifying and managing a LAST event. By having more awareness, knowledge, and confidence in managing LAST, maternal morbidity and mortality should decrease during a LAST event. It is recommended that labor and delivery floors implement formal training along with simulation to create more awareness of LAST and to increase knowledge and confidence in managing a LAST event.


***KEYWORDS****:* local anesthetics, local anesthetic systemic toxicity, LAST, maternity, obstetrics, parturient, simulation-based training, intralipids, and emergency checklist

## BACKGROUND AND SIGNIFICANCE

Local Anesthetic Systemic Toxicity (LAST) is a high-acuity, low-occurrence medical emergency caused by increased plasma concentrations of local anesthetics (Mock et al., 2021). Inadvertent intravenous injection, accelerated absorption, exceeded dosing volumes, or delayed drug clearance can precipitate LAST (Bern & Weinberg, 2011; Mock et al., 2021). Approximately 1 to 2 LAST events transpire per 1000 regional nerve blocks, which includes epidurals (Macfarlane et al., 2021). Early signs and symptoms of LAST can occur within the first minute of administration and up to 30 minutes or more after the initial dose (Ferguson et al., 2019). When early signs and symptoms such as tinnitus, confusion, and tingling around the mouth go unidentified, symptoms can quickly progress to respiratory and cardiac arrest (Ferry & Cook, 2020). Although LAST events are infrequent, they still contribute to maternal morbidity and mortality (Mock et al., 2021).

In the parturient population, labor pain is commonly relieved by local anesthetic administration. Approximately 73% of women elect to have an epidural or spinal anesthetic during childbirth (Butwick et al., 2018). The parturient population is also of higher susceptibility to a LAST event. Physiological changes during pregnancy, such as decreased alpha-1-acid glycoprotein levels, increased cardiac output, and engorgement of epidural veins, increase the risk of LAST (Mock et al., 2021). Edematous airways, aortocaval compression, and decreased functional residual capacity complicate LAST management and patient resuscitation in the pregnant population (Bern & Weinburg, 2011). Providing early intervention is critical to preventing poor outcomes for mothers and babies.

Bowsher et al. (2018) identified poor LAST awareness among providers in the maternity care setting, which included physicians, midwives, nurses, and other support personnel. Even

though local anesthetics were widely used in the high-risk maternity population, providers could not identify early signs and symptoms of LAST (Bowsher et al., 2018). While educating all providers is necessary, educating Labor and Delivery (L&D) nurses is pertinent. Nurses are the eyes and ears of the doctors and the patient's advocate. L&D nurses spend more time with the patients and will most likely be the first to witness and identify the signs and symptoms of a LAST event. Their knowledge of LAST is vital to early identification and intervention and increasing better outcomes for mothers and babies. Due to the rarity of LAST, there is a high chance that most nurses have never encountered a LAST event during their clinical training.

Implementing formal education, simulation, and cognitive aids increases awareness, reduces interventional delays, and provides treatment steps in low-frequency/high-risk events like LAST (Bevil et al., 2020; Ferguson et al., 2019; Ferry et al., 2020). Event-specific simulation provides different learning experiences that allow for the application of knowledge and skills related to that event (Park et al., 2010). Event-specific simulation enhances knowledge and skill retention for that event (Park et al., 2010). Even though simulation is associated with increased knowledge and skills retention, recall in duress can lead to human recall error; therefore, step-by-step checklists are recommended to reduce omissions and errors.

During a crisis, knowledge recall may be unreliable and lead to omission or delay of proper treatment (Hepner et al., 2017). Implementing checklists significantly reduces medical errors and improves patient outcomes in crisis events (Hepner et al., 2017). Therefore, providing the American Society of Regional Anesthesia and Pain Medicine (ASRA) LAST checklist will prompt L&D nurses to take the correct steps to manage their patients. By providing formal education, simulation, and cognitive aids such as a checklist, L&D nurses will have increased knowledge, knowledge retention, confidence, and readiness during a LAST event.

## PURPOSE

Local anesthetics, such as epidurals, CSE, spinals, and other regional blocks, are common in laboring women. Maternal mothers have an increased risk of experiencing a LAST event. Even though LAST events are uncommon, it is vital to identify early signs and symptoms and appropriately intervene for the safety of the mother and baby. Delayed interventions could lead to maternal and fetal death. By utilizing current research on LAST, multiple interventions can be done to increase awareness, readiness, and timely response to recognizing and treating LAST in mothers. Education and a scripted simulation will be implemented and evaluated for its effects in increasing awareness, knowledge, confidence, and perceived benefits through pre-and post-surveys.

## LITERATURE REVIEW

### Search Strategy

The literature review completed examined the years 2010 to 2022. Databases searched included CINAHL, Google Scholar, MEDLINE, PubMed, and Scopus. The literature review search used the Boolean operators AND/OR for the keywords: local anesthetics, local anesthetic systemic toxicity, LAST, maternity, obstetrics, parturient, simulation-based training, intralipids, and emergency checklist. The analysis included peer-reviewed articles, academic journals, prospective cohort studies, case reports, and a pilot study. Key terms produced a total of 47 articles. After excluding commentaries, non-peer-reviewed articles, duplicates, and non-relevant studies, the paper utilized 19 articles, focusing on LAST pharmacodynamics, manifestations, treatment, prevention, education, simulation, and checklists.

## Local Anesthetics in Obstetrics

Local anesthetics are commonly used for pain control due to their effectiveness and low risk for adverse events. Since the 1960s, epidural analgesia has been considered the gold standard for labor pain due to its superior efficacy in pain relief compared to alternative methods such as nitrous oxide, intravenous opioids, and other non-pharmacological methods (El-Wahab & Robinson, 2014). Approximately 73% of women receive epidurals or spinals to relieve labor pain (Butwick et al., 2018). Not only are local anesthetics widely utilized for labor pain, but they are also utilized for intraoperative and postoperative analgesia for cesarean sections along with vaginal or cervical laceration repairs. Administration of local anesthetics may be delivered via subcutaneous infiltration, pudendal, transversus abdominis plane, paravertebral, or iliohypogastric and ilioinguinal blocks, which reduce postoperative pain and opioid requirements (Mitchell et al., 2019). Many of these techniques use moderate to high amounts of local anesthetics, thereby increasing the risk of LAST.

## Mechanism of Action of Local Anesthetics

Local anesthetics reversibly bind to voltage-gated sodium channels and inhibit cells from depolarizing (Macfarlane et al., 2021; Mock et al., 2021). The inhibition of nerve impulses prevents the transmission of pain and temperature signals; thus, the patient feels no pain (Macfarlane et al., 2021). As the plasma concentration increases, potassium and calcium channels become affected. Blocking these potassium and calcium channels prevents the brain and heart tissue from depolarizing, leading to severe complications. (El-Boghdadly et al., 2018; Ferry & Cook, 2020; Macfarlane et al., 2021).

Local anesthetics are classified as an amide or ester, which determines the route of metabolism. Esters are metabolized by plasma esterases, causing rapid metabolism of local

anesthetics. Amides are hepatically metabolized; therefore, they metabolize much more slowly and allow local anesthetic buildup in the plasma. Consequently, administering amide local anesthetics will likely cause LAST (El-Boghdadly et al., 2018; Macfarlane et al., 2021). Amide local anesthetics, such as Bupivacaine and ropivacaine, are commonly used in neuraxial (epidural and spinals) anesthesia. The most toxic local anesthetic to the brain and heart tissues happens to be Bupivacaine, which leads to a higher incidence in LAST (Macfarlane et al., 2021).

**Incidence of LAST**

LAST is a low-occurrence, high-acuity event. Approximately 1 in 500 patients will experience symptoms of LAST, and 1 in 10,000 patients who receive epidurals will require resuscitation due to LAST (El-Boghdadly & Chin, 2016; Macfarlane et al., 2021). An overview of case reports revealed that 28% of LAST cases were paravertebral, epidural blocks, intraurethral, intravaginal, or perineal nerve blocks (Macfarlane et al., 2021). However, the LAST incidence is likely higher, and lack of awareness leads to misdiagnosis and underreporting (Gitman & Barrington, 2018; Macfarlane et al., 2021). Misdiagnoses or delayed treatment in LAST puts the mother and baby at significant risk for morbidity and mortality. All L&D nurses must understand the diagnosis and treatment of last to decrease morbidity and mortality when LAST occurs.

**Risk Factors**

Causes of LAST include exceeded max doses/volumes of local anesthetics, inadvertent intravenous injection, vascularity/absorption of injection sites, administration techniques, and patient factors/comorbidities (Macfarlane et al., 2021; Mock et al., 2021). The parturient population has more inherent risk factors for LAST due to several physiologic changes during pregnancy. During pregnancy, the cardiac output increases, alpha-1-acid glycoproteins decrease,

and vascularity of epidural space increases, leading to higher circulating plasma concentrations of local anesthetics (Macfarlane et al., 2021). Screening the parturient population for other comorbidities that further increase the LAST risk is pertinent. Comorbidities that increase LAST risk include end-stage renal disease, cardiac disease, hepatic disease, or other conditions that further reduce local anesthetics' protein binding (El-Boghdadly et al., 2018). Factors that can exacerbate LAST and reduce protein binding include hypoxia, hypercarbia, and acidosis (El-Boghdadly & Chin, 2016).

**Manifestations**

Early signs and symptoms of central nervous system (CNS) toxicity include metallic taste, tinnitus, periorbital numbness, blurred vision, and excitement or agitation (Ferguson et al., 2019; Ferry & Cook, 2020; Mock et al., 2021). As peak plasma concentration rises, seizures will occur, the most common presenting complication. If left untreated, it will progress to more severe complications such as respiratory depression, respiratory arrest, and cardiac arrest (Gitman et al., 2018; Macfarlane et al., 2021). Because local anesthetics also work on calcium and potassium channels, blockade of these channels can lead to cardiovascular involvement.

Early signs and symptoms of cardiovascular involvement include new onset of hypertension and tachycardia (El-Boghdadly et al., 2018; Ferguson et al., 2019). As LAST progresses, cardiac depression occurs and precipitates as cardiac arrhythmias (worsening bradycardia), conduction abnormalities (prolonged PR and QRS intervals), hypotension, ventricular tachycardia, and torsade's de points, all leading to cardiovascular collapse (El-Boghdadly & Chin, 2016; Ferguson et al., 2019). Therefore, delayed diagnosis or treatment of LAST will consequently result in respiratory and cardiac arrest requiring Advanced Cardiac Life

Support (ACLS), drastically increasing the morbidity and mortality rate for both mother and baby.

**Treatment and Management**

LAST should be suspected if complications occur after administering a local anesthetic. The most crucial step in treating LAST is administering lipid emulsion therapy (LET) as soon as possible. Early administration of LET significantly reduces morbidity and mortality associated with a LAST event and is the definitive treatment. LET can stop LAST's progression and reduce complications such as respiratory or cardiac arrest (Bern & Weinburg, 2011). LET's exact mechanism of action is unknown. The theory of the LET mechanism is that it extracts local anesthetics from the tissues, such as the brain and heart, back into the vessels (Bern & Weinburg, 2011; Mock et al., 2021). As intralipid therapy enters the vessels, it interacts and binds with the local anesthetic, lowering the concentration of plasma free drug (Ferguson et al., 2019).

Management of LAST involves initiating the intuition's LAST protocol and team efforts. After identifying a LAST event, the first step is calling for help and discontinuing any local anesthetic infusion (e.g., epidural infusion). While waiting for help, applying oxygen and maintaining an airway is essential to prevent hypoxemia, hypercarbia, and respiratory acidosis (El-Boghadadly & Chin, 2016). If a seizure occurs, the patient should be immediately treated with benzodiazepines since seizures exacerbate LAST by causing hypoxemia and metabolic acidosis (Macfarlane et al., 2021). Administering propofol should be conservative as it is a myocardial depressant and may cause further cardiovascular instability (Macfarlane et al., 2021). If the patient's conditions progress to cardiovascular instability or cardiac arrest, a modified version of ACLS should be followed.

The modified ACLS protocol utilizes smaller epinephrine doses, less than 1 mcg/kg since larger doses of epinephrine inhibit the LET mechanism of action. Using local anesthetics, vasopressin, potassium channel blockers, and calcium channel blockers is contraindicated and associated with poorer outcomes; therefore, they should be avoided (El Boghdadly & Chin, 2018). Quality chest compressions are essential as they allow LET therapy to circulate and reverse LAST toxicity. In the obstetric population, patients should be positioned for left uterine displacement to reduce aortocaval compression and increase cardiac output (Bern & Weinberg, 2011; Mock et al., 2021). Providers can proficiently manage and treat LAST by incorporating the ARSA checklist for LAST (Appendix D).

**ASRA Checklist**

Implementing cognitive aids reduces errors and omissions related to knowledge recall in rare crisis events (Hepner et al., 2017). In a previous study, anesthesia residents who relied on knowledge recall during a LAST simulation had significantly more inconsistencies than those who utilized the ASRA checklist. Mismanagement of care included omission of steps, improper drug dosing, such as wrong LET dose, and utilizing ACLS drugs improperly compared to those who utilized the ASRA checklist that includes the modified ACLS drugs (Neal et al., 2010). Those who utilized the ASRA checklist provided more consistent evidence-based practice care and performed better in nontechnical skills. Since the management of LAST hinges upon proper LET administration, it is quintessential that the ASRA checklist is utilized during a LAST event. Implementation will improve early diagnosis, reduce medical errors, and improve patient outcomes.

**Simulation Training**

Baseline knowledge of LAST improved with various types of education: web-based online modules, video presentations, educational posters, and power points (Edwards et al., 2018; Ferguson et al., 2019; Ferry & Cook, 2020). However, knowledge retention declined after implementing traditional education methods (Ferry & Cook, 2020). When pairing traditional education methods with high-fidelity simulation, there was a marked improvement in both knowledge retention and skills (Park et al., 2010).

Implementing high-fidelity simulation allows learners to undergo experiential learning through realistic scenarios in a safe environment and translates education into clinical practices (Hanshaw & Dickerson, 2020). It provides the unique opportunity to experience events such as LAST before exposure in the clinical setting. Utilizing simulation allows learners to debrief and evaluate team and self-performance. Simulation proves superior in progressively gaining and retaining technical and nontechnical skills (Bevil et al., 2020; Park et al., 2010). Critical thinking skills, self-efficacy, self-confidence, clinical judgment, and knowledge improved significantly after the simulation (Bevil et al., 2020; Hanshaw & Dickerson, 2020).

Nurses participating in a LAST simulation had significantly higher post-intervention scores of 90% compared to 52% pre-intervention scores (Bevil et al., 2020). After participating in the LAST simulation, nurses felt more confident and equipped to facilitate the management of LAST (Bevil et al., 2020). Teamwork, communication, and situational awareness also improved (Bevil et al., 2020). Pairing education with high-fidelity simulation will improve the recognition and treatment of LAST.

### Gaps

Among current literature, few publications examine the LAST simulation compared to conventional interventions. Studies of LAST simulation among L&D nurses were not found, and limited studies examined LAST awareness and response to stimulation among perioperative nurses. Due to the rarity of LAST, no studies have looked at direct patient outcomes and the transference of knowledge and skills regarding LAST. However, self-reports from anesthesia providers contributed to their success in treating LAST after undergoing LAST simulations eight weeks prior (Smith et al., 2008). They believed simulation was crucial to their rapid problem-solving skills and prompt recognition and proper treatment (Smith et al., 2008).

## THEORETICAL FRAMEWORK

The theoretical approach implemented in this DNP project was based on Kolb's Experiential Learning Theories. Kolb's theory was grounded in the idea that learning came from real-world experiences or "learning by doing." His theory assumes that people learn best when involved in active learning, and the individual must discover that knowledge to create change. It requires reflection to create a meaningful experience (Kolb & Kolb, 2017). In experiential learning, learners can have direct contact with the subject, allowing them to investigate, explore, and create judgments. The Experiential Learning Theory consists of a four-stage cycle that transforms learners' experiences into knowledge (Kolb & Kolb, 2017). The four-stage cycle consists of concrete experience, reflective observation, abstract conceptualization, and active experimentation, and at any point, the learner can enter the cycle (Kolb & Kolb, 2017).

Since LAST rarely occurs, participants were given a short educational presentation. After completion of the presentation, participants experienced the first step in the learning cycle through a mock simulation of LAST. Simulation allows learners to be actively engaged and

obtain the substantial experience required for acquiring new knowledge. The second cycle step, abstract conceptualization, was completed by a debriefing session immediately after the simulation. The debriefing session allowed participants to reflect and ask the project investigator (PI) any questions. The next step allowed participants to undergo abstract conceptualization by completing a post-survey about their perception of knowledge and confidence regarding LAST. The fourth step in the learning cycle is left entirely up to the participants as it requires participant learners to put their knowledge into practice and partake in implementing new evidence-based practices. The fourth step was evaluated by asking participants if the intervention changed their practice.

## METHODS

### Design

The project utilized a mixed methods cross-sectional design. Pre-and post-surveys (Appendix A, B, and C) were designed to evaluate the effectiveness of educational intervention which comprised of a PowerPoint presentation and a LAST simulation (Appendix E and F). Data was collected from the pre- and post-surveys (Appendix A, B, and C) to address the following question: Does the incorporation of education, simulation, and ASRA checklist on LAST improve labor and delivery nurses' knowledge and confidence in recognizing and treating LAST? Qualitative questions examined perceptions of changes in practices and barriers to practice changes.

### Translational Framework

The Iowa Model of Evidence-Based Practice is designed to facilitate and implement new evidence-based practices in the healthcare setting to improve the quality of care (Buckwalter et al., 2017). It provides a step-by-step process to aid clinicians in utilizing robust and reliable

research and translating it into new evidence-based practices (Buckwalter et al., 2017). The model helps define what strong research includes such as multiple resources, various methods, high consistency, and low biases (Buckwalter et al., 2017). It consists of five steps and feedback loops. The five steps include problem identification, forming a team, critique of relevant research, implementing practice change, and dissemination of findings.

The first step involves identifying an issue and determining if it is a priority for the organization. Issues are problem-focused triggers or knowledge-focused triggers. Problem-focused triggers include risk management data, process improvement data, internal/external benchmarking data, financial data, and the identification of clinical problems (Buckwalter et al., 2017). Knowledge-focused triggers include new research or literature, national agencies or organizational standards and guidelines, philosophies of care, and questions from institutional standards committees (Buckwalter et al., 2017). This project identified the clinical problem of a knowledge gap among many labor and delivery nurses to identify the signs and symptoms of LAST and facilitate the proper treatment interventions. The second step involved forming a team: a DNP student, a clinical CRNA resource, and the University of North Carolina at Greensboro (UNCG) faculty advisor. The third step involved assembling, critiquing, and synthesizing research and literature relevant to LAST in the obstetric population and nursing staff. The fourth step involved implementing practice changes in the clinical setting. L&D nurses were presented with an educational presentation, a simulation, and an ASRA checklist. Lastly, this project's results were disseminated during poster presentation day at the University of North Carolina at Greensboro and to the quality improvement department of the participating hospital.

**Sample/ Setting**

The project occurred in a 208-bed acute care hospital's labor and delivery department, which contained 15 beds and delivered approximately 2,400 babies annually. Convenience sampling was used and consisted of nurses directly involved in patient care. Inclusion criteria included nurses working on the labor and delivery floor more than fifty percent of the time. Exclusion criteria included float pool nurses who spend less than fifty percent of their time in the labor and delivery department and other L&D healthcare professionals.

A recruitment letter was given via email prior to the implementation of this project and was located on their communication board inside the breakroom. The recruitment letter conveyed the purpose of the DNP project, a description of the educational presentation and simulation, and information about the pre-and post-surveys (Appendix A, B, and C). An information sheet was then distributed to potential participants, going over participants' rights, potential associated risks, and the PI's contact information for additional questions and concerns. Voluntary participation was emphasized, and there would be no consequences for not participating. Participants were able to withdraw at any time with no penalty.

**Implementation**

Multiple implementation sessions were held to target day and night shift nurses along with weekend shifts. During huddles, the charge nurse would inform nurses that they were invited to participate in the project during or after their shift. Participants completed pre-test surveys (Appendix A) and listened to a PowerPoint presentation followed by a scripted simulation (Appendix E and F). The PowerPoint presentation covered LAST pathophysiology, early signs and symptoms, and managing and treating LAST in the parturient population. After the presentation, participants partook in a scripted simulation based on a case study. Participants

were asked to volunteer for roles in the script, such as charge nurse, nurse one, and nurse two. Reading through the script helped facilitate learning the new location of intralipids, utilizing the ASRA checklist, and prompting questions related to the nurse's role and responsibilities. The scripted simulation utilized a real case scenario that highlight early signs and symptoms after the administration of an epidural in a laboring mom. After implementation, nurses immediately completed post-intervention surveys (Appendix B) to assess initial gained knowledge and confidence. Pre- and Post-surveys were placed in sealed envelopes and handed to the PI. After a month, the post-intervention surveys (Appendix C) were administered again to examine knowledge retention. One-month follow-up surveys were collected in a folder and picked up by the personal investigator two weeks after the distribution of the surveys. **Permissions**

After approval was obtained from the UNCG Institutional Review Board (IRB), approval was obtained through the Quality and Improvement Department at the hospital. CRNA sponsorship was obtained through the anesthesia department, which helped coordinate and oversee the capstone project. The CRNA was a point of contact for locating intralipid therapy and coordinating efforts to make intralipid therapy available directly on the L&D floor.

**Data Collection**

After completing the intervention, pre- and post-test surveys (Appendices A, B, and C) were placed in sealed envelopes and returned to the PI. The Knowledge pre-test survey (Appendix A) established a baseline knowledge for LAST. In contrast, the Likert-Scale pre-test survey (Appendix A) examined perceptions of knowledge, confidence, and effectiveness of education and simulation. After four weeks of implementation, post-interventional surveys were placed in a dividing folder in the L&D breakroom and collected in the same folder. After two weeks, the PI picked up the one-month follow-up post-interventional surveys.

Data collection remained anonymous by using unique identifiers. Unique identifiers used the mother's birthday, followed by the last two digits of their phone number. By utilizing unique identifiers, all surveys could be linked and analyzed while minimizing risks to participants. Collected surveys were then stored by the UNCG faculty advisor upon completion of this project. Data will be stored for three years per UNCG policy and then shredded appropriately.

**Instruments**

Two pre-test tools were developed (Appendix A): the Knowledge Pre-Test and the Likert Scale Pre-Test. The Knowledge pre-test contained short multiple-choice questions to assess baseline knowledge of LAST, such as early signs and symptoms, range of symptoms mild to severe, risk factors, treatment, and most toxic local anesthetic. The Likert Scale Pre-Test examined the perception of knowledge, confidence, treatment, location of intralipid therapy and ASRA checklist, roles and responsibilities, and simulation benefits.

The knowledge post-test tool and the Likert-Scale post-test survey were administered immediately after intervention and again one month after implementation. The knowledge post-test survey allowed assessment for immediately gained knowledge after intervention and retention of LAST knowledge one month later. The Likert-Scale post-test assessed for perception changes in knowledge and confidence immediately after intervention and one month later. The Likert-Scale post-test had additional questions to assess for LAST practice changes and barriers. A free text comment section was available to describe perceived barriers to that specific department.

**Data Analysis**

Data collected from both pre-test surveys were entered into Microsoft Excel. Immediate post-test surveys were entered in accordingly. Thirty-six L&D nurses had completed the pre-test

surveys, but only thirty-two (n=32) immediate post-intervention surveys were collected; therefore, the four unpaired surveys were disregarded. Data was then analyzed using paired t-tests and descriptive statistics. Data was separated into knowledge survey pre-and post-test and Likert-scale pre-and post- test. The Likert-scale survey was divided into the following categories: knowledge, confidence, management, roles and responsibilities, and simulation.

After one month passed, data was collected again and analyzed for significant changes such as knowledge retention and decreased confidence. The knowledge immediate post-test survey was compared to the one-month post-test, again utilizing paired t-tests and descriptive statistics. The Likert-scale immediate post-test survey was compared to the one-month post-test survey similarly.

Paired t-test of two sample means was conducted using an alpha level of 0.05, and a P two-tail value $< 0.05$ was considered statistically significant. Descriptive statistics were used to assess baseline knowledge, confidence, and retention. The total means of test scores and individual questions were examined in the knowledge survey (Appendix A, B, and C), and the total means of each category in the Likert-scale survey (Appendix A, B, and C). The Likert-scale post-test surveys contain unpaired questions at the end to assess for perceived change of practice, need for intervention, and barriers to implementation. The PI created the surveys and they were not tested for validity or reliability.

**Budget, Time, and Resources**

Incentives were utilized to encourage participation in this project. Five-dollar gift cards were awarded to participants who completed all the following: pre-intervention survey, PowerPoint presentation, and scripted simulation, and completed immediate post-intervention surveys. Participants who completed the one-month follow-up post-intervention surveys were

entered into a random drawing for a fifty-dollar gift card. Approximately five to ten minutes were required to introduce participant rights and complete pre-intervention surveys. The educational PowerPoint presentation took approximately 10-15 minutes and had time variations related to participant questions. Approximately 10-15 minutes were utilized to run through the scripted simulation. Reviewing the ASRA checklist and locating the nearest lipid emulsion therapy took less than five minutes, and filling out the post-intervention surveys took about five minutes. In four weeks, surveys were distributed again and allotted another five minutes for completion. A designated statistician reviewed instrument design, data, and results.

**RESULTS**

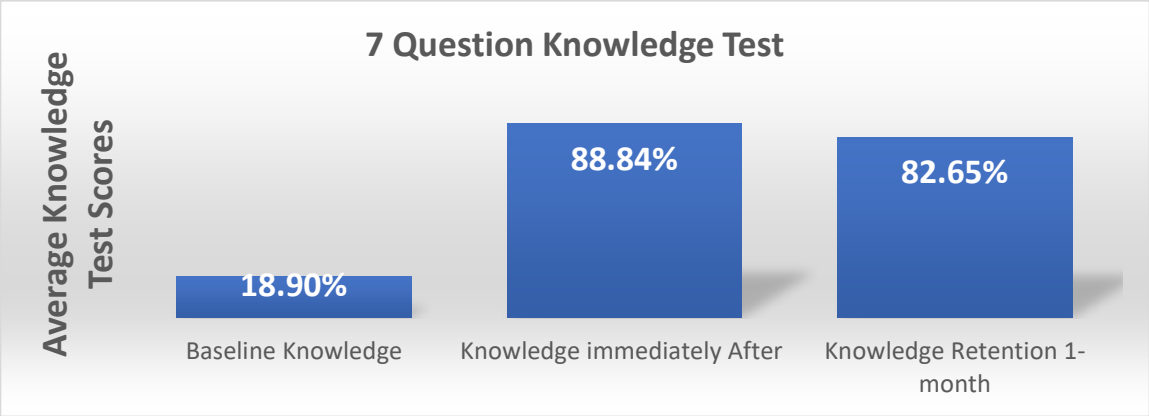
Participants received a knowledge evaluation and Likert-scale survey pre-intervention, post-intervention, and one month later during follow-up (Appendix A, B, and C). The knowledge evaluation test included seven multiple choice questions to obtain nurses' baseline knowledge on LAST signs and symptoms, increased risk factors, definitive treatment, and most toxic local anesthetic. The Likert Scale survey assessed their perceived confidence and knowledge on LAST signs and symptoms, treatment and management, intralipid therapy and ASRA checklist location, roles/responsibilities, and benefits of simulation training. After the implementation of the intervention, surveys (Appendix B) were immediately handed out to the participating nurses. The post-test Likert scale contained additional questions to assess practice changes and any perceived barriers. One month after the intervention, post-test surveys (Appendix C) were distributed again to assess knowledge retention and changes in confidence.

The knowledge pre-test revealed an overall all-average test score of 18.33% from the thirty-two participants. The first question asked whether the individual knew what LAST was, and 87.5% of participants answered, "do not know what LAST is." Only four of the thirty-two

participants answered that they knew LAST before implementation. The second question asked to identify the early signs and symptoms of LAST, and 50% of participants chose "I do not know what LAST is," while 31% chose the correct answer. The third question assessed if participants knew all LAST symptoms ranging from mild to severe, which revealed that only four of the thirty-two participants could identify all symptoms. 50% of participants chose the "I do not know what LAST is" answer. The fourth question asked participants to identify conditions that potentiate LAST, and nine out of thirty-two participants identified the correct answer. In contrast, twenty out of thirty-two participants answered, "I do not know what LAST is." The fifth question asked participants to choose the condition that does not increase the risk for LAST, and nine out of thirty-two participants chose correctly. This question did not have the answer choice, "I do not know what LAST is," so participants had to select a condition listed. Question six asked what the definitive therapy for LAST is, and three of the thirty-two participants chose intralipid therapy. The last question of this survey asked which local anesthetic is the most toxic, and two of the thirty-two participants chose bupivacaine.

Immediately after the PowerPoint presentation and scripted simulation, the knowledge post-test revealed a significant increase in the overall average test scores. The overall test score average improved from 18.3% to 88.84%. Approximately 94% could identify early signs and symptoms of LAST and recognized that bupivacaine was the more toxic local anesthetic. Fourteen of the thirty-two participants identified all mild to severe LAST symptoms, which totaled 43.75%. Twenty-nine participants identified the conditions that potential LAST, which totaled 90.6%. 96.87% of participants could identify the condition that did not increase the risk for LAST.

After one month, the knowledge post-test was distributed again. Fourteen of the thirty-two participants completed the test. The fourteen linked surveys were assessed for knowledge retention. The fourteen participants scored an average of 90.82% on their original knowledge post-test. After one month, the total average score dropped to 82.65%. 100% of participants identified LAST's early signs and symptoms and the definitive treatment. Being able to identify all mild to severe symptoms of LAST declined from 57.14% to 35.71%. Identifying conditions that potentiate LAST decreased from 85.71% to 78.57%. For choosing the condition that does not increase the risk for LAST, the score declined from 92.85% to 71.4%. 85.7% chose the correct, most toxic local anesthetic. A paired t-test was utilized on total average scores, which revealed a p-value of 0.044. A p-value of 0.044 revealed a significant knowledge retention decline one month after intervention.

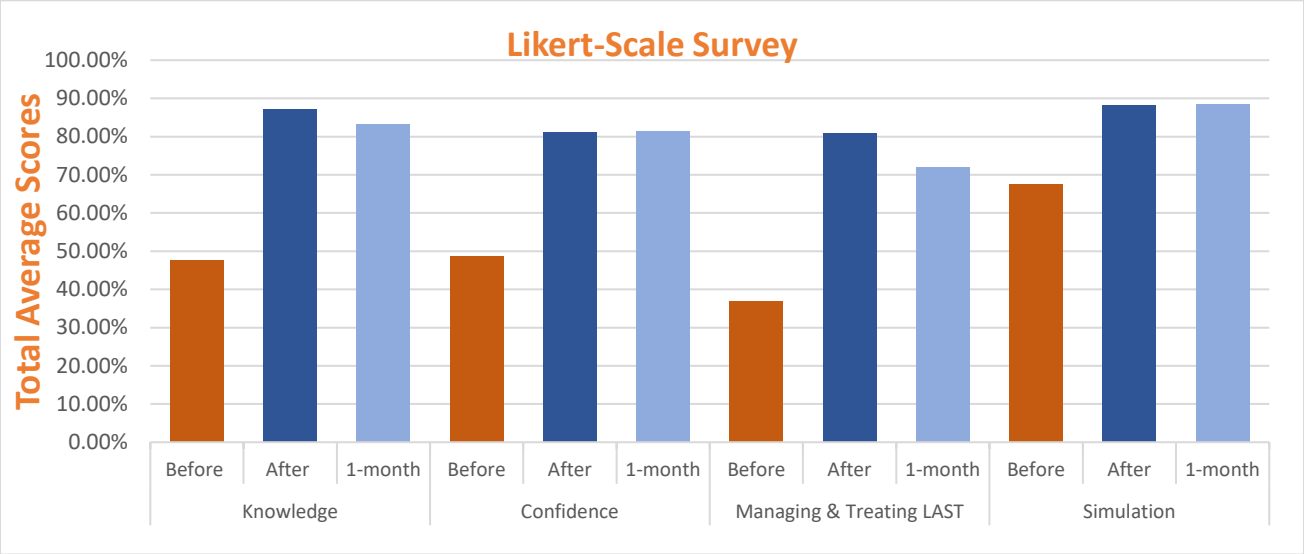



The Likert-scale survey (Appendix A) required participants to utilize a scale of 1 to 5, with 1 being "strongly disagree," 3 being "undecided," and 5 being "strongly agree." This survey contained six categories: knowledge, confidence, location, management, roles and responsibilities, and perception of education and simulation. Participants rated the categories before and after implementation and again one month after. Questions #4, #12, #14 addressed confidence. Questions #1, #2, and #3 related to general knowledge of LAST. Questions #6 and

#7 were locating the ASRA checklist and intralipid therapy. Questions #5, #8, #9, #10, and #11 were about the management and treatment of LAST. Question #13 examined roles/responsibilities, and question #15 examined perceptions of simulation prior to implementation. Questions #17 through #21 assessed for perception of practice change, vigilance in educating patients and assessing signs and symptoms, implementation for new-hire orientation, and barriers.

Paired t-tests compared the six categories for pre-and post-Likert scale surveys (Appendix A). Results revealed increased average mean scores in all six categories, with p-values less than alpha 0.05 indicating clinical significance. For the category of knowledge, the mean score increased by approximately 40%. Most nurses agreed they understood the cause of LAST, knew that bupivacaine was more toxic than ropivacaine and that pregnancy increased the risk for LAST. For the confidence category, the mean score increased by approximately 33%, with most nurses agreeing that they felt confident in recognizing initial signs and symptoms of LAST and managing a LAST event. For the management category, the mean scores increased by 44%, with most of the nurses agreeing they knew the initial interventions in LAST treatment, how to utilize the ASRA checklist, dose lipid emulsion therapy, which medications to avoid, and utilizing the modified BLS/ACLS protocol. For the location category of intralipid therapy and the ASRA checklist, there was an increase of 45% in mean scores. For the roles/responsibilities category, there was an increase in mean scores by 50%, and for simulation, there was an increase in mean scores by 21%. Most nurses ranked undecided in the pre-intervention survey questions and agreed after the intervention.

After one month, the Likert-scale follow-up survey (Appendix C) was distributed, and fourteen of the thirty-two participants completed the surveys. The fourteen linked surveys were utilized to examine knowledge retention and changes in confidence and practice. Paired t-tests revealed no statistical differences from an original post-intervention survey in the following categories: total knowledge (p-value 0.34), total confidence (p-value 0.58), total location (p-value 0.21), and roles and responsibilities (p-value 0.67). Scores for total managing and treatment of LAST and simulation category declined and revealed statistical differences. The original post-intervention score for management and treatment was 78.3%, and after one month, it declined to 72% with a p-value of 0.03. The original post-intervention for simulation was 84.3% and declined to 77.1% after one month with a p-value of 0.002.




Most nurses rated the educational presentation and scripted simulation as beneficial for increasing confidence and management of LAST and agreed that simulation was superior to presentation alone. All nurses agreed they have changed their practice since participating in this intervention and are more vigilant in educating and assessing patients for signs and symptoms of LAST. Approximately 44% of nurses rated "strongly agree," and 53% of nurses agreed they

assess for signs and symptoms frequently after implementation. All nurses either agreed or strongly agreed that they had changed their practice since participating in the project and believed that implementing the PowerPoint and scripted simulation would be beneficial for implementing it into new-hire orientation.

When rating barriers to implementation and practice changes, perceptions varied in responses. Seven respondents disagreed or strongly disagreed that barriers existed against implementing this project. Eight respondents were undecided if there were barriers. Seventeen either agreed or strongly agreed that there were barriers to implementing the PowerPoint and scripted simulation into practice. One comment stated that "belief of importance" was a barrier noted, and another stated "approval, schedules, and resistance to change." In another comment on barriers being present, one stated, "management not being aware, MDs not communicating about LAST, RNs not wanting to speak up or want to implement change." The one-month follow-up survey had similar responses and reiterated the issue of coordinating education and the time it takes to create and implement LAST policies. One nurse suggested in the barrier's comments section that intralipid therapy and the ASRA checklist should be linked to an order set in EPIC when epidural orders were placed. She also recommended that a LAST navigator be utilized for prompt steps in management and documentation.

## DISCUSSION

Before implementing this project, nurses in the L&D unit most likely had not received formal LAST education or training during nursing school. Most nurses responded that they did not know what LAST was, and only four of the thirty-two participants responded that they did. Of those four respondents who knew what LAST was, the overall knowledge pre-test scores were approximately 43%. The overall knowledge pre-test scores of 18.9% identified a

knowledge deficit. The Likert-scale pre-intervention survey revealed poor awareness, knowledge, and lack of confidence in identifying and managing a LAST event, which has been demonstrated to go hand in hand since lack of training or hands-on experience correlates with low confidence (Kim et al., 2020). Before implementing this project, a LAST event would likely have delayed diagnosis, increasing the chances for mismanagement, morbidity, and mortality and contributing to the theory that LAST is underreported (Neal et al., 2017).

The knowledge pre-test score revealed that 28% of nurses could identify early signs and symptoms of LAST even though most answered they did not know what LAST is. Educated guesses could have been made based on the questions anesthesia providers ask the patient after epidural placement. Only 15% of nurses could identify all LAST symptoms. Approximately 22% believed pregnancy did not increase the risk for LAST, and 12.5% identified the definitive treatment. After the presentation and simulation, 30 out of 32 participants identified LAST's early signs and symptoms. Twelve of thirty-two nurses identified all LAST signs and symptoms. All 32 participants identified pregnancy as an increased risk for LAST and that intralipid therapy was the definitive treatment. Based on other studies that utilized both traditional and simulation education, it was expected to see an increase in scores and a decrease in knowledge gaps (Bevil et al., 2020; Hanshaw & Dickerson, 2020; Park et al., 2010).

Improving knowledge in L&D nurses will help reduce morbidity and mortality associated with LAST events and increase provider's confidence, leading to prompt recognition and treatment. As anticipated, the Likert-scale post-survey revealed that nurses felt more knowledgeable and confident in identifying, treating, and managing a LAST. Confident providers in their knowledge and skills deliver the utmost quality patient care (Kim et al., 2020). Simulation allows L&D nurses to gain clinical experience in a LAST event, which builds

confidence and reduces anxiety simultaneously (Kim et al., 2020; Labrague et al., 2019). When preparing for low occurrence-high acuity events like LAST, it is essential to simulate this type of medical emergency and have policies in place that guide diagnosis and treatment. Nevertheless, knowledge scores did decline 8.17% one month after implementation, which was anticipated. Fourteen participants completed the one-month follow-up survey, and their total score dropped from 90.82% to 82.65%. Two of the fourteen participants had an increased score, which was not anticipated. Nurses may have reviewed materials after implementation, which could explain the increase in scores. Those who encounter the same information repetitively will likely retain knowledge (Doomernik et al., 2016). However, those who experience one encounter with no refresher are likely to experience knowledge declines as early as one week and at varying rates over time (Doomernik et al., 2016; Hanshaw & Dickerson, 2020). After the intervention, the L&D nurses will likely continue to experience a decline in knowledge retention as time passes. Studies show that multiple simulation encounters over time are linked to higher scores, confidence, performance, and knowledge retention (Hanshaw & Dickerson, 2020). To maintain knowledge and confidence, labor and delivery nurses should do a LAST simulation periodically.

During implementation, it was determined that L&D nurses needed access to intralipid therapy and the ASRA checklist; therefore, intralipid therapy and the ASRA checklist were placed in a secured epidural cart. Some nurses had participated in the intervention before gaining access to the intralipid therapy and ASRA checklist, which most likely explains why some nurses chose "undecided or disagree" on their post-intervention surveys. It was recommended that all nurses be updated on the new location of intralipid therapy and the ASRA checklist.

Most participants found this intervention on LAST beneficial and agreed it should be part of the new hire orientation process. Post-intervention surveys revealed that nurses changed their practice accordingly. Nurses educated patients, assessed for signs and symptoms of LAST, and were more vigilant in their assessments. However, there were perceived barriers to implementing this project, such as issues with belief in its relevance, the time it takes to implement, resistance to change, coordinating an interdisciplinary team, and streamlining communication. One nurse commented in barriers, "It would be great for orientation for new hires, and it would be easier to give undivided attention rather than trying to do the intervention during a shift." During the project implementation, a new anesthesia group transitioned into the hospital and had several new providers. Creating an interdisciplinary team with anesthesia providers and labor and delivery nurses would be ideal for creating floor policies on LAST and removing barriers described by the participants. Several participants had excellent ideas for improving LAST barriers, such as creating a LAST navigator in EPIC that signals signs and symptoms to watch for and can activate when a LAST event is suspected.

## LIMITATIONS

Several limitations were noted for this project. Staffing for this labor and delivery floor had approximately 80 nurses, which included full-time, part-time, and per diem positions. Nurses preferred participating in the project during scheduled staffing hours rather than before or after shifts. Several time slots were allotted to maximize participation; however, there was an overlap in staff on certain implementation days. Since the project was presented during staffing hours, some nurses had to leave to partake in patient care, and several nurses monitored patients during the presentation. Four nurses left during implementation to attend to patients, which explains why 36 pre-test surveys were collected but only 32 post-test surveys were collected. After a

month of implementation, post-surveys were placed in the breakroom. Only 14 surveys from the original 32 participants were completed. This could be due to various reasons, such as travel nurses, vacations, or per diem nurses not working shifts during the data collection timeframe. Also, the study does not examine knowledge retention over a long-term span and cannot determine its long-term effects.

Due to set clinical schedules, the principal investigator could not provide more flexible schedules to include all staff schedules and time frames. Ideally, the timeframe to collect data would have been extended, but due to timelines for this project, it was shorter than anticipated. The inflexible schedule and short timeframe could have contributed to having a smaller sample size. Another limitation is that convenience sampling was used, which could lead to selection bias. Participants who participated in this intervention may not be able to characterize those who did not participate, preventing generalization of these results.

## RECOMMENDATIONS FOR FUTURE

Due to time constraints for nurses on the unit already, it may be more plausible to utilize an online presentation and interactive simulated event for intervention. Moving from an in-person to an online intervention may maximize participation and data collection. Participants could utilize this during staffing hours and pause and restart whenever needed, and it would include all staffing schedules. This project also utilized a scripted simulation that did not allow participants to engage in problem-solving to apply acquired knowledge. By providing a simulated event that prompts critical thinking, learners may retain more knowledge and confidence. While this project targets labor and delivery nurses, it could be utilized and modified for other labor and delivery department providers, such as certified nurse assistants, midwives, and obstetricians. It could also be adapted for other departments utilizing local anesthetics or for

rapid response teams and code blue teams to increase awareness and proper management of LAST during a suspected or confirmed LAST event.

With knowledge retention declining, further research should explore this educational tool's long-term effectiveness. Several factors play into knowledge retention and could be utilized further to increase the effectiveness of the presentation or simulation. This project only looked at the effects of implementing education and simulation once versus multiple interactive sessions. Also, the study did not examine the long-term effects to determine how often implementation should be repeated to maintain maximum knowledge and confidence related to LAST. At a minimum, it should be implemented annually to maintain minimal knowledge on LAST, such as early signs and symptoms, definitive treatment, and the ability to locate intralipid therapy and the ASRA checklist.

## CONCLUSION

This project aimed to increase awareness, knowledge, and confidence in identifying and managing LAST among L&D nurses while examining knowledge retention. This project also evaluated practice changes and the benefits of scripted simulation. Implementing a LAST PowerPoint presentation and scripted simulation increased awareness, knowledge, and confidence in identifying and managing LAST among L&D nurses. Participants agreed that utilizing simulation was beneficial, and most had changed their practice to incorporate new knowledge in educating patients about LAST and assessing for signs and symptoms more frequently. All participants agreed that this project would benefit their practice and recommended it be implemented into their new-hire orientation.

Therefore, it is recommended that all L&D nurses receive formal LAST education during new hire orientation and become familiar with the location of intralipid therapy and the ASRA

checklist. Providing LAST education and simulation will further reduce the LAST knowledge gap identified in various studies among the labor and delivery departments. By providing formal training during orientation, patients experiencing a LAST event will likely have significantly improved outcomes and reduced morbidity and mortality. However, there was a significant decline in knowledge retention after one month. Due to the inability to study the effectiveness of long-term knowledge retention for this LAST project, it is recommended that annual training be conducted to maintain minimal knowledge of identifying and managing LAST.

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## APPENDIX A

Participant ID:_____

(Mother's birthday (mm/dd/yy), and last two digits of your phone number)

### Local Anesthetic Systemic Toxicity (LAST)

### Instructions

Unique identifiers will be assigned to each participant. The creation of these unique identifiers will allow for linking pre-and post-intervention surveys and keeping your responses anonymous. Please follow the format above to create your participant ID and put your participant ID in the designated section at the top of this page.

### Demographic Survey

1. Are you a registered nurse? (Circle your answer choice) Yes No
2. Do you spend greater than or equal to 50% of your time working on the labor and delivery floor? (circle your answer choice) Yes No
3. How long have you been practicing ?
    a. Less than 1 year
    b. Between 1-5 years
    c. Between 5-10 years
    d. Greater than 10 years
4. Age
    a. <25 years
    b. 25-35 years
    c. 35-45 years
    d. >45 years
5. Gender _____

## Pre-Intervention Surveys

**Knowledge Pre-Test**

1. Do you know what LAST is?
    a. Yes
    b. No
2. Early signs and symptoms of LAST include:
    a. Autonomic instability, hyperthermia, blurred vision
    b. Tinnitus, periorbital numbness, and metallic taste
    c. Muscle rigidity and tachycardia
    d. I do not know what LAST is.
3. LAST symptoms range from mild to severe. Identify all LAST symptoms. Select all that apply:
    a. Seizures
    b. Tachycardia and hypertension
    c. Confusion
    d. Asystole
    e. Tinnitus
    f. I do not know what LAST is.
4. Identify the conditions that potentiate LAST.
    a. Hypoxia, hypercarbia, metabolic acidosis
    b. Hypocarbia, metabolic alkalosis
    c. Hyperventilation, respiratory alkalosis
    d. I do not know what LAST is.
5. Which condition does NOT increase the risk for LAST?
    a. Liver disease
    b. Pregnancy
    c. Obesity
    d. Mild renal disease
6. What is the definitive treatment for LAST?
    a. Intralipid therapy
    b. Benzodiazepines
    c. Modified BLS/ACLS
    d. I do not know what LAST is.
7. Which local anesthetic is most toxic?
    a. Bupivacaine
    b. Ropivacaine
    c. Lidocaine
    d. I do not know.

**Pre-Test Likert-scale Survey**

**SD: (strongly disagree); D: (disagree); UN: (undecided): A: (agree); SA: (strongly agree)**

| Questions | SD | D | UN | A | SA |
|---|---|---|---|---|---|
| 1. I understand the cause of LAST. | | | | | |
| 2. I know that bupivacaine is the more toxic than ropivacaine | | | | | |
| 3. I know that pregnancy increases the risk of LAST due to physiologic changes | | | | | |
| 4. I am confident in my ability to recognize initial signs and symptoms of LAST. | | | | | |
| 5. I know the initial interventions in LAST treatment. | | | | | |
| 6. I know where the closest LAST kit/cart is located. | | | | | |
| 7. I know the location of ASRA checklist. | | | | | |
| 8. I know to utilize the ASRA checklist during a LAST event. | | | | | |
| 9. I know how to dose lipid emulsion therapy. | | | | | |
| 10. I know which medications to avoid during LAST. | | | | | |
| 11. I understand to use modified BLS/ACLS as described in the ASRA checklist in the maternal population. | | | | | |
| 12. If a LAST event were to occur, I feel confident in my abilities to manage that patient. | | | | | |
| 13. I understand my role and responsibilities during a LAST crisis event. | | | | | |
| 14. A LAST educational presentation and simulation are beneficial to increase confidence and competence in managing a LAST event. | | | | | |
| 15. Simulation education is superior to a PowerPoint or online module alone in teaching the management of a LAST event. | | | | | |

## Appendix B

Participant ID:_____

(Mother's birthday (mm/dd/yy), and last two digits of your phone number)

### Local Anesthetic Systemic Toxicity (LAST)

### Instructions

Unique identifiers will be assigned to each participant. The creation of these unique identifiers will allow for linking pre-and post-intervention surveys and keeping your responses anonymous. Please follow the format above to create your participant ID and put your participant ID in the designated section at the top of this page.

### Post-Intervention Survey

**Knowledge Post-Test**

1. Do you know what LAST is?
    a. Yes
    b. No
2. Early signs and symptoms of LAST include:
    a. Autonomic instability, hyperthermia, blurred vision
    b. Tinnitus, periorbital numbness, and metallic taste
    c. Muscle rigidity and tachycardia
    d. I do not know what LAST is.
3. LAST symptoms range from mild to severe. Identify all LAST symptoms. Select all that apply:
    a. Seizures
    b. Tachycardia and hypertension
    c. Confusion
    d. Asystole
    e. Tinnitus
    f. I do not know what LAST is.
4. Identify the conditions that potentiate LAST.
    a. Hypoxia, hypercarbia, metabolic acidosis
    b. Hypocarbia, metabolic alkalosis
    c. Hyperventilation, respiratory alkalosis
    d. I do not know what LAST is.
5. Which condition does NOT increase the risk for LAST?
    a. Liver disease
    b. Pregnancy
    c. Obesity

   d. Renal disease
6. What is the definitive treatment for LAST?
   a. Intralipid therapy
   b. Benzodiazepines
   c. Modified BLS/ACLS
   d. I do not know what LAST is.
7. Which local anesthetic is most toxic?
   a. Bupivacaine
   b. Ropivacaine
   c. Lidocaine
   d. I do not know.

**Post-Test Likert-scale Survey**
**SD: (strongly disagree); D: (disagree); UN: (undecided): A: (agree); SA: (strongly agree)**

| **Questions** | **SD** | **D** | **UN** | **A** | **SA** |
|---|---|---|---|---|---|
| 1. I understand the cause of LAST. | | | | | |
| 2. I know that bupivacaine (Marcaine) is the more toxic than ropivacaine | | | | | |
| 3. I know that pregnancy increases the risk of LAST due to physiologic changes | | | | | |
| 4. I am confident in my ability to recognize initial signs and symptoms of LAST. | | | | | |
| 5. I know the initial interventions in LAST treatment. | | | | | |
| 6. I know where the closest LAST kit/cart is located. | | | | | |
| 7. I know the location of ASRA checklist. | | | | | |
| 8. I know to utilize the ASRA checklist during a LAST event. | | | | | |
| 9. I know how to dose lipid emulsion therapy. | | | | | |
| 10. I know which medications to avoid during LAST. | | | | | |
| 11. I understand the modified BLS/ACLS as described in the ASRA checklist in the maternal population. | | | | | |
| 12. If a LAST event were to occur, I feel confident in my abilities to manage that patient. | | | | | |
| 13. I understand my role and responsibilities during a LAST crisis event. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 14. A LAST educational presentation and simulation are beneficial to increase confidence and competence in managing a LAST event. | | | | | |
| 15. Simulation education is superior to a PowerPoint or online module alone in teaching the management of a LAST event. | | | | | |
| 16. I have changed my practice since participating in this project. | | | | | |
| 17. I am more vigilant in educating patient the signs and symptoms of LAST and assessing for LAST more frequently. | | | | | |
| 18. I assess for signs and symptoms of LAST more frequently | | | | | |
| 19. Implementing this PowerPoint and simulation for new-hire and orientation would be beneficial. | | | | | |
| 20. There are barriers from implementing practice changes. | | | | | |
| If yes, what are the barriers? | | | | | |

Appendix C

Participant ID:_____

(Mother's birthday (mm/dd/yy), and last two digits of your phone number)

**Local Anesthetic Systemic Toxicity (LAST)**

**Instructions**

Unique identifiers will be assigned to each participant. The creation of these unique identifiers will allow for linking pre-and post-intervention surveys and keeping your responses anonymous. Please follow the format above to create your participant ID and put your participant ID in the designated section at the top of this page.

**1 Month Follow-up Post-Intervention Surveys**

**1 Month: Knowledge Post-Test**

1. Do you know what LAST is?
    a. Yes
    b. No
2. Early signs and symptoms of LAST include:
    a. Autonomic instability, hyperthermia, blurred vision
    b. Tinnitus, periorbital numbness, and metallic taste
    c. Muscle rigidity and tachycardia
    d. I do not know what LAST is.
3. LAST symptoms range from mild to severe. Identify all LAST symptoms. Select all that apply:
    a. Seizures
    b. Tachycardia and hypertension
    c. Confusion
    d. Asystole
    e. Tinnitus
    f. I do not know what LAST is.
4. Identify the conditions that potentiate LAST.
    a. Hypoxia, hypercarbia, metabolic acidosis
    b. Hypocarbia, metabolic alkalosis
    c. Hyperventilation, respiratory alkalosis
    d. I do not know what LAST is.

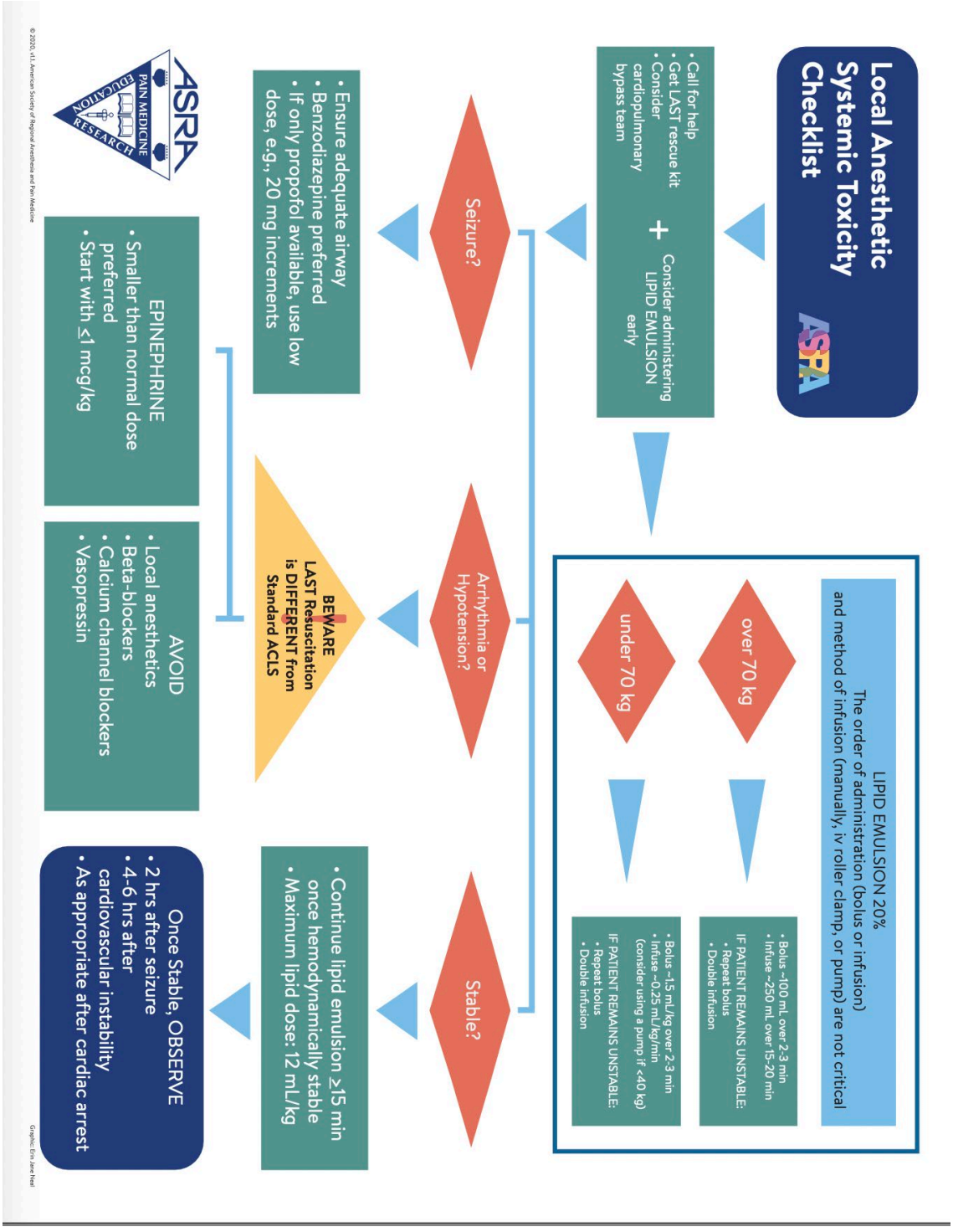
5. Which condition does NOT increase the risk for LAST?
    a. Liver disease
    b. Pregnancy
    c. Obesity
    d. Renal disease
6. What is the definitive treatment for LAST?
    a. Intralipid therapy
    b. Benzodiazepines
    c. Modified BLS/ACLS
    d. I do not know what LAST is.
7. Which local anesthetic is most toxic?
    a. Bupivacaine
    b. Ropivacaine
    c. Lidocaine
    d. I do not know.

**1 Month: Post-Test Likert Scale Survey**
**SD: (strongly disagree); D: (disagree); UN: (undecided): A: (agree); SA: (strongly agree)**

| **Questions** | **SD** | **D** | **UN** | **A** | **SA** |
|---|---|---|---|---|---|
| 1. I understand the cause of LAST. | | | | | |
| 2. I know that bupivacaine (Marcaine) is the more toxic than ropivacaine | | | | | |
| 3. I know that pregnancy increases the risk of LAST due to physiologic changes | | | | | |
| 4. I am confident in my ability to recognize initial signs and symptoms of LAST. | | | | | |
| 5. I know the initial interventions in LAST treatment. | | | | | |
| 6. I know where the closest LAST kit/cart is located. | | | | | |
| 7. I know the location of ASRA checklist. | | | | | |
| 8. I know to utilize the ASRA checklist during a LAST event. | | | | | |
| 9. I know how to dose lipid emulsion therapy. | | | | | |
| 10. I know which medications to avoid during LAST. | | | | | |
| 11. I understand the modified BLS/ACLS as described in the ASRA checklist in the maternal population. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 12. If a LAST event were to occur, I feel confident in my abilities to manage that patient. | | | | | |
| 13. I understand my role and responsibilities during a LAST crisis event. | | | | | |
| 14. A LAST educational presentation and simulation are beneficial to increase confidence and competence in managing a LAST event. | | | | | |
| 15. Simulation education is superior to a PowerPoint or online module alone in teaching the management of a LAST event. | | | | | |
| 16. I have changed my practice since participating in this project. | | | | | |
| 17. I am more vigilant in educating patient the signs and symptoms of LAST and assessing for LAST more frequently. | | | | | |
| 18. I assess for signs and symptoms of LAST more frequently | | | | | |
| 19. Implementing this PowerPoint and simulation for new-hire and orientation would be beneficial. | | | | | |
| 20. There are barriers from implementing practice changes. | | | | | |
| If yes, what are the barriers? | | | | | |

# Appendix D


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 min
• Infuse ~250 mL over 15-20 min
IF PATIENT REMAINS UNSTABLE:
• Repeat bolus
• Double infusion
under 70 kg
• Bolus ~1.5 mL/kg over 2-3 min
• Infuse ~0.25 mL/kg/min (consider using a pump if <40 kg)
IF PATIENT REMAINS UNSTABLE:
• Repeat bolus
• Double infusion
Seizure?
Arrhythmia or Hypotension?
Stable?
• Ensure adequate airway
• Benzodiazepine preferred
• If only propofol available, use low dose, e.g., 20 mg increments
BEWARE
LAST Resuscitation is DIFFERENT from Standard ACLS
• Continue lipid emulsion ≥15 min once hemodynamically stable
• Maximum lipid dose: 12 mL/kg
EPINEPHRINE
• Smaller than normal dose preferred
• Start with ≤1 mcg/kg
AVOID
• Local anesthetics
• Beta-blockers
• Calcium channel blockers
• Vasopressin
Once Stable, OBSERVE
• 2 hrs after seizure
• 4-6 hrs after cardiovascular instability
• As appropriate after cardiac arrest
ASRA
PAIN MEDICINE EDUCATION RESEARCH
© 2020, v1.1 American Society of Regional Anesthesia and Pain Medicine
Graphic: Erin Jane Neel

**Appendix E**


## Why does it matter for labor and delivery nurses?

- Approximately 4 in 10,000 epidurals experience LAST
- If LAST is misdiagnosed or receives delayed treatment, the mother and baby are at significant risk for morbidity and mortality
- This population has more inherent risk factors for LAST due to several physiologic changes during pregnancy.
  - Increased cardiac output
  - Decreased alpha-1 acid glycoproteins
  - Increased vascularity of epidural space

## What is LAST?

Last is due to an excess plasma concentration of local anesthetic

It is affected by the rate of absorption into the systemic circulation and by metabolism

It can be influence by type of local anesthetic, vascularity of site, use of epinephrine, and dosing

## Cause of LAST

- Most common cause is IV injection during a peripheral nerve block or epidural anesthesia
- Large doses
- Rapid absorption

## Factors that increase risk of LAST

**Pregnancy**

- Decrease alpha-a-glycoprotein levels, increased cardiac output, and engorgement of epidural veins

**Obesity**

**Liver disease**

## Early signs and symptoms of LAST

**CNS**

- Periorbital numbness
- Sensory changes (auditory, visual, taste)
- Muscle twitching
- Lightheadedness, dizziness
- Restlessness
- Agitation
- Seizures

**CVS**

- Tachycardia
- Hypertension
- Palpitation

# Late Signs and Symptoms of LAST

**CNS:**

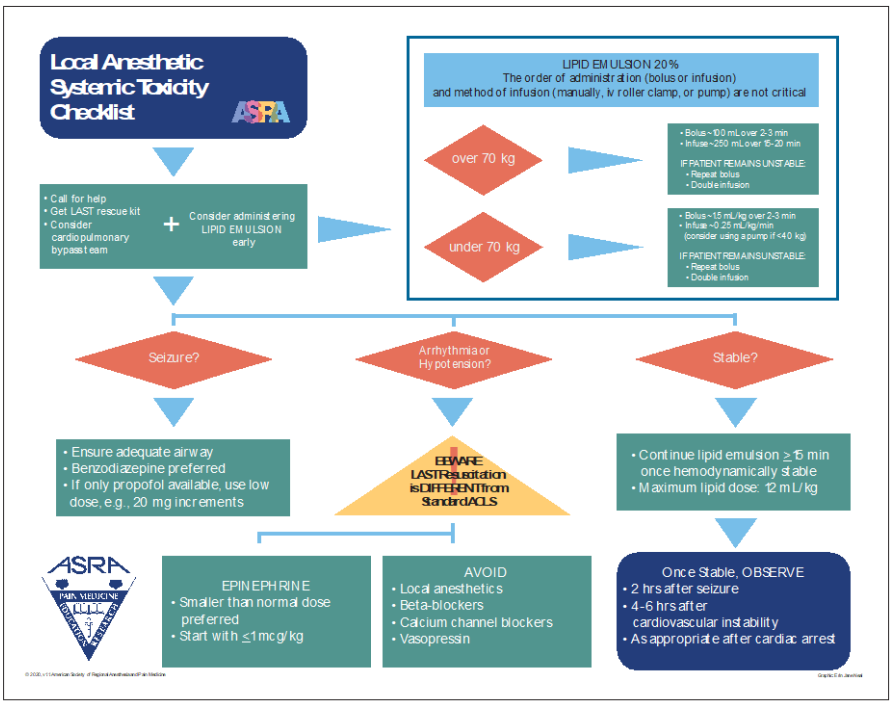
- Decreased or loss of consciousness
- Coma
- Respiratory arrest

**CVS:**

- Hypotension
- Bradycardia
- Heart block
- Ventricular ectopy
- Cardiovascular collapse
- Cardiac arrest

# What to do in a LAST event

- Call for help
- Support airway and ventilation with 100% oxygen
- Avoid acidosis, hypercarbia, and hypoxemia
- Stop seizures: benzodiazepines preferred method
- **Administer lipid emulsion therapy!**
  - **This is the definitive treatment!**
  - **Studies have shown the faster you administer, the better the outcomes**
- Cardiopulmonary bypass




# Managing a LAST code:

## Modified BLS

- Place patient in left uterine displacement
- Reduces aortocaval compression syndrome and improves cardiopulmonary resuscitation
- Bag-valve mask 100%

## Modified ACLS

- Epinephrine </= 1 mcg/kg
- AVOID:
  - local anesthetics
  - beta-blockers
  - calcium channel blockers
  - vasopressin

# Your Role

- Inform the patient to notify you if they have any changes in sensory (metallic taste, ringing in the ears, and numbness or tingling around the mouth, or blurred vision)
- Monitor the patient closely within first 30 mins
- Be able to identify early signs and symptoms associated with LAST
- Familiarize yourself with location of intralipid emulsion therapy and ASRA checklist
- Assume any changes in patient are related to local anesthetic

# Case Study

- A 28-year-old primigravida, weighing 75 kg, presented at 38 weeks gestation in active stage of labor. Patient requested an epidural, which was placed in L1-L2 space. A test dose was administered and confirmed placement of epidural prior to administered 8 mL of isobaric bupivacaine (0.25%) with 100 mcg of fentanyl.
- After 15 mins, the patient suddenly became agitated and displayed twitching of her face and limbs. Blood pressure was 168/110 mm hg and heart rate 120 beats/min and fetus heart deceleration was observed.
- Patient transported to operating room immediately due to suspected diagnosis of LAST. Lipid emulsion therapy was administered based on 1.5 ml/kg of 20% intralipid and then repeated again in 10 mins.
- An emergency caesarean section was done .
- Patient returned back to baseline within 20 mins and displayed no neurological symptoms and baby was delivered safely. No subsequent events were observed.

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## Appendix F

**LAST Demonstration Script**

*This scenario is based on a case study that happened among a labor and delivery floor. Changes in dosing intralipid therapy have been made to reflect the latest publish ASRA checklist.*

Roles:
Primary nurse
Secondary nurse
Anesthesia provider

Scenario:
A 28-year-old primigravida, weighing 75 kg, presented at 38 weeks' gestation in active stage of labor. An epidural is placed in the L1-L2 space. After a test dose was administered, epidural placement was confirmed, and patient received 8 mL of isobaric bupivacaine (0.25%) with 100 mcg of fentanyl.

After 15 minutes from epidural placement, patient is suddenly agitated and experiencing twitching of her face and limbs.
VS:

- Blood pressure is 168/110
- Heart rate is 120 beats/minute
- Fetal heart deceleration occurs
- Oxygen saturation is 88%
- Respiratory rate is 22 breaths/minute

Recognizing a LAST Event:

| Responsibility | Action |
|---|---|
| Primary nurse | Recognize signs and symptoms of LAST and call for help and LAST kit/cart.<br>1. Stop continuous infusion of local anesthetic.<br>2. Activate Rapid Response Team<br>3. Stay with patient to assess vitals and manage potential further complications (e.g. seizures, hypoxia, apnea).<br>1. Ensure patient has a working large bore IV.<br>2. Ensure adequate airway and ventilation.<br>3. Monitor for arrythmias, hypotension, and fetal distress.<br>4. Communicate with team of further changes. |
| Secondary nurse (First nurse to respond to help) | 1. Locate the intralipids and bring to patient's room.<br>2. Grab ASRA checklist and begin following protocol.<br>3. Patient is > 70 kg-→ bolus 100 ml of intralipids 20% over 2-3 minutes. Initiate lipid emulsion therapy immediately.<br>4. Continue infusing intralipids 20% at 250 mLs over 15-20 minutes. |
| Charge nurse | 1. Call obstetrician, anesthesiology team, and NICU team<br>2. Initiate procedures for potential emergency C-section and potentially distressed baby. |

Patient transported to OR for stat C-section.

| Responsibility | Action |
|---|---|
| Primary nurse | 1. Give anesthesia provider report. Include information of when intralipids was started and dose. |
| Anesthesia provider/CRNA | 1. Takes over management of airway.<br>2. Ensure the continuation of intralipid 20% therapy.<br>3. Will determine if a repeat bolus is required.<br>4. Repeat bolus dose is given. |

Patient returns to baseline after 20 minutes from starting intralipid therapy and baby is safely delivered.

| Responsibility | Action |
|---|---|
| Primary nurse | 1. Patient is transported to PACU.<br>2. Continue monitoring for signs and symptoms for reoccurrence of LAST event. |
| Anesthesia provide/CRNA | 1. Discontinue epidural and ensure tip is intact.<br>2. Give handoff to primary nurse.<br>3. State that patient received a repeat bolus of intralipids 20% of 100 ml over 2-3 minutes.<br>4. Patient is hemodynamically stable, and no LAST symptoms have been observer |