Local Anesthetic Systemic Toxicity (LAST): Designing an Educational Effort for Nurses That Will Last

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Purpose: *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.*
Design: *An evidence-based practice project design.*
Methods: *Nurses in units where nerve block procedures were performed (ie, postanesthesia care unit, preoperative, operating room, outpatient services, labor and delivery unit) received a pretest about their knowledge of LAST events, participated in a 30-minute educational session, and then completed a post-test. The data were analyzed for differences and statistical significance. Included in the test was a question about the nurse's comfort level with managing a LAST event.*
Findings: *The findings demonstrated a knowledge deficit related to LAST events. The average of all three units combined pretest scores was 60% and post-test scores increased to 95%. The average comfort level of all three units was 3.5/10 (35%) before the educational in-service program and increased to 7.9/10 (79%) after education.*
Conclusions: *Nurses working in units where nerve blocks are performed are lacking in knowledge of the signs and symptoms and the correct course of treatment for a LAST event. This could lead to poor outcomes of a very high-risk low-volume event.*

Keywords: *local anesthetic, peripheral nerve blocks, lipid emulsion, cardiotoxicity.*

LOCAL ANESTHETIC SYSTEMIC TOXICITY (LAST) is a potentially life-threatening event in which a bolus of local anesthesia (LA) is inadvertently injected into peripheral tissue or venous or arterial circulation during a peripheral nerve block (PNB) or spinal nerve block procedure where it is rapidly absorbed into systemic circulation, resulting in cardiovascular and or neurologic collapse.[1,2] Registered nurses (RNs) assist certified registered nurse anesthetists (CRNAs) or anesthesiologists with block procedures and must be aware of the early signs and symptoms so that correct treatment can be initiated immediately. Research has shown that early and rapid intervention and use of intravenous lipids during a LAST event can greatly improve patient survival rates.

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Pharmacodynamics

During a normal block procedure, LA works by rapidly moving through the cell membrane of neurons and blocks the opening of the sodium, potassium, or calcium ion channels, preventing the depolarization of the fiber and passing of sensory information, thus "blocking" the sensory and motor function of the nerve.[2] In a LAST event, the LA is picked up by the local blood vessels and is absorbed into systemic circulation, where it accumulates in high toxic levels, resulting in adverse effects on the heart and/or brain.[1,2] The systemic absorption of injected LA is determined by several factors, the most important being dose and injection site.

The amount of drug bound to the tissue, local tissue blood flow, use of vasoconstrictors, and the physicochemical properties of the drug selected also affect systemic uptake and ultimately blood concentration of the LA. The highest plasma levels of LA are dependent on the regional anesthesia injection site. In rank order of highest to lowest, intercostal, caudal, epidural, brachial plexus, and finally the sciatic nerve has the lowest uptake of LA.[3]

The cardiovascular effects of LA can block cardiac sodium channels depressing normal cardiac pacemaker activity, excitability, and conduction. At extremely high concentrations, local anesthetics can also block calcium channels. This can also depress myocardial contractility and produce direct arteriolar dilation, leading to systemic hypotension. Therefore, calcium channel blockers are to be avoided in a LAST resuscitation. Cardiovascular collapse is rare, but has been reported with bupivacaine and ropivacaine in large doses.[3]

Bupivacaine has been found to be potentially more cardiotoxic than other long-acting local anesthetics (eg, ropivacaine). This is potentiated by the long action potential duration of cardiac cells compared with nerve fibers. Commonly the electrocardiography (ECG) finding in patients with elevated bupivacaine plasma levels is a slow idioventricular rhythm with broad QRS complex and eventually pulseless electrical activity. Resuscitation from bupivacaine cardiovascular toxicity is extremely difficult even for experienced clinicians. Supportive care and advanced cardiac life support (ACLS) guidelines along with LAST treatment protocols should be followed.

LAST Symptoms

The onset of symptoms has been reported to occur in as little as 56 seconds and up to 30 or more minutes after the injection of the LA has been administered.[2,4,5] Therefore, it is important to maintain continuous monitoring and assessment during blockade procedures. Early symptoms of LAST may include a metallic taste, circumoral numbness, auditory changes (eg, tinnitus), blurred vision, shivering, excitement and agitation, nausea, vomiting, or diarrhea.[2,4,6] Patients may slur their speech, become suddenly drowsy or confused, complain of lightheadedness, have fine tremors of the hands, and exhibit signs of cardiovascular excitement such as initial hypertension and tachycardia.[2,4,5] These symptoms can quickly progress to more severe symptoms such as seizures, coma, respiratory depression, and cardiovascular depression including progressive bradycardia and conduction block delays such as prolonged PR and QRS intervals, hypotension, ventricular tachycardia, ventricular fibrillation, and Torsades de Pointes resulting in cardiovascular collapse.[2,4,6,7]

The initial focus and treatment of LAST is on airway management, seizure suppression, and management of cardiovascular collapse. A complete step-by-step guide for providers to follow during a LAST event, *Checklist for Treatment of Local Anesthetic Systemic Toxicity* was created by The American Society of Regional Anesthesia and Pain Medicine and has been adopted into many US facilities including Kootenai Health (Figure 1).

ACLS Guideline Modifications

The ACLS algorithm recommends adjustment of epinephrine to less than 1 mcg/kg and the avoidance of certain medications including propofol, vasopressin, calcium channel blockers, beta blockers, and local anesthetic with the addition of lipid emulsion therapy.[2,4] Propofol is a cardiovascular depressant, which may send the patient further into cardiovascular collapse, and contains a lipid content too low to provide benefit.[4] Often ventricular fibrillation can be seen on the cardiac monitor, with the provider

Figure 1. Checklist for treatment of local anesthetic systemic toxicity. Reprinted with permission from ASRA, © 2011 The American Society of Regional Anesthesia and Pain Medicine. This figure is available in color online at www.jopan.org.

starting cardiopulmonary resuscitation as an initial response following the ACLS algorithm. Following ACLS protocol for ventricular fibrillation unfortunately will not correct a LAST event, as additional bolus of epinephrine may send the patient into further cardiovascular collapse and may act to reduce the efficacy of lipid rescue efforts.[4]

Lipid Therapy

Current research recommends lipid emulsion therapy for treatment of a LAST event. Lipid emulsion therapy provides a "lipid sink" or pool of lipids that bind with the fat-loving LA, thus pulling it out of tissues and reducing the concentrations of LA in the patient's blood, halting, and reducing the severe symptoms and consequences of LAST.[2,8,9] The basic function of the lipid emulsion is to provide the circulating lipids a potential and possibly more favorable binding site for LA molecules. Local anesthetics have lipophilic and protein binding properties. Binding of LA molecules to the lipid infusion removes it from binding to the sodium channels

and decreases the complications of LAST. Normal metabolism of the LA molecules continues until complete excretion by the kidneys.

Complications of lipid therapy have not been widely studied in human subjects but several documented adverse effects on pateints have been reported such as hypersensitivity reactions to soybeans or egg proteins, complex fat overload syndrome, and acute respiratory distress syndrome.[8,10] Patients with compromised liver, pancreas, or kidney function can experience an exacerbation in these underlying conditions.[8] A theoretical risk of lipid-induced pancreatitis has also been noted when lipid rescues have been done.[11]

Although the RN does not order the lipids during a LAST event, the RN should facilitate patient safety at all times. This includes early recognition and communication of LAST symptoms, knowledge of lipids, and the location of rapid infusion tubing.[4,9] Early identification and treatment of LAST is key to patient survival and must be addressed emergently. The RN should immediately call for help and stay with the patient to maintain the airway while ventilating with 100% oxygen, assist with basic and advanced cardiac support, and be prepared to assist with the rapid administration of lipids.[2,5,12]

Depending on the state's nurse practice act and organizational policy, an RN may only inject local anesthetic through the peripheral nerve catheter under the direct observation of the anesthesiologist and may essentially act as the anesthesiologist's extra set of hands.[4,12] The RN may not insert the device, administer the initial test dose into the nerve plexus, confirm placement of the needle, or establish dose parameters to achieve analgesia pain relief.[4,12,13]

Description of the Problem

Nurses working in areas where block procedures are performed must be both knowledgeable and efficient in providing rescue methods in the event of a LAST occurrence. Nurses in our facility did not possess the knowledge or the confidence to ensure that they fully understood how to manage a LAST event. Because a LAST event is rare, measuring an improvement in patient outcomes is not feasible.

Setting of the Project

This evidence-based project was performed at a level II trauma center, 292-bed community owned hospital in Northern Idaho. The educational intervention was provided to 70 RNs in the perianesthesia preoperative (Pre-Op), postanesthesia care units (PACUs), operating room (OR), labor and delivery (L&D) unit, and outpatient services (OS).

Literature Review

The literature review supported development and refinement of the practice question, identification of gaps in best practice, potential interventions, and implementation methods. The stakeholders used the John Hopkins Nursing Evidence-Based Tools to review and appraise the literature. The evidence-based practice (EBP) question established was, in nurses who work in areas where block procedures are performed, will implementation of an evidence-based educational intervention about LAST events improve both their knowledge and confidence?

Search Strategy

The key search terms used were local anesthetic systemic toxicity (LAST), registered nurse, lipid rescue, procedural blocks, education, and LAST events. The key terms produced a combined total of 22 articles. Further exclusions included peer-reviewed articles, academic journals, publications from 2008 to 2017, and removal of duplicates. After these exclusions were applied, a total of 19 articles were then reviewed for relevance to the research question, with a final review of 10 articles. The articles focused on LAST pathophysiology, treatment, and prevention of LAST events. The articles were assessed for interventions that were used to address education of staff that assist and the care of patients having a LAST event. There were limited articles directed at the education of nurses on LAST events. The databases included CINHAL, PubMed, ERIC, MedLine, Joanna Briggs Institute, Cochrane Library, and PsycINFO.

Project Design

This project used an EBP project design based on a modified Iowa Model.

Step 1. Identify Gaps

The first step in the EBP project design started with identifying a gap in knowledge of best practice. We identified that there was a lack of knowledge and best practices related to a LAST event among nurses in the perianesthesia units.

Step 2. Identify Stakeholders

A perianesthesia nurse formed a team of key stakeholders and developed an interprofessional team consisting of CRNAs, physicians, a pharmacist, and nurses.

Step 3. Literature Review and Evaluation of the Evidence

Because there was a lack of understanding of best practice, this step was critical. Although sparse, the literature was clear, and consultation with content experts identified and defined best practices.

Step 4. Translating the Evidence

The nurse clearly identified the goal for the EBP project, which was to develop a formal emergency protocol so that all nurses working in areas that performed regional blocks would have a solid knowledge base of what a LAST event was and how to treat it. The CRNAs and physicians shared their knowledge of the pathophysiology of LAST and assisted with developing talking points that should be included in the education.

Implementation

A perianesthesia nurse formed a team of key stakeholders and developed an interprofessional team consisting of CRNAs, physicians, pharmacist, and nurses. The nurse clearly identified the two goals for the EBP project.

1. All RNs who are working in areas that perform local blocks will know the signs and symptoms of a LAST event.
2. If a LAST event occurs there will be a process in place and all RNs who are working in areas where local blocks are performed will know exactly what to do and where to find the supplies.

The process began by obtaining knowledge of the pathophysiology, signs and symptoms, and treatment of LAST through the CRNAs, physicians, and within the literature. This knowledge was the foundation for the educational intervention and the development of a 10-question test (Table 1). The 10-question test was developed to assess the nurses knowledge of a LAST event and was reviewed with a nurse educator for question clarity and format. Questions included the anatomy and physiology of a block, identifying the signs and symptoms of LAST, location of the lipids, and the nurses overall comfort level of their role during a LAST event. A 30-minute training session was developed, which clearly explained what a LAST event was, signs and symptoms, and treatments. Training sessions were established within units and usually presented at monthly staff meetings where the nurse gave learners a pretest, presented information with the aid of a power point presentation board and empty medication examples followed by a post-test. The tests were graded and results were entered into an Excel spreadsheet for review and comparison.

Pharmacy staff identified the units in which lipids were currently stocked and the two keywords that nurses could type into the Pyxis medication dispensing system to obtain the lipids. The original keywords were uncommon and awkward and caused delay in the retrieval of the lipids. As a result, pharmacy changed the search terms to two common terms familiar to nurses, “Lipid” and “Liposyn” resulting in fast identification and quick retrieval of the lipids by unit RNs. Through collaboration with pharmacy all lipids are now stocked in departments where peripheral, spinal, and epidural block procedures are performed. All bags have an attached, Checklist for Treatment of LAST (Table 1), as a quick reference guide for administration in a LAST event.

Outcomes and Statistical Analysis

A survey measuring comfort level (range, 1 = not comfortable at all and 5 = very comfortable) and

Table 1. PACU: Prepresentation Knowledge Measurement Tool for LAST

LAST is a potentially life-threatening event in which a bolus of local anesthetic is inadvertently injected into _____ and/or _____ circulation during a block procedure. It is then rapidly absorbed into systemic circulation, resulting in _____collapse. (Fill in the blank.)
What can the RN do prior to the initiation of peripheral or spinal block? (Circle all that apply.)
A. Verify consent, allergies and past reactions to blocking agents.
B. Check IV access and patency.
C. Establish procedural time-out.
D. Verify availability of emergency equipment.
E. Place patient on continuous monitoring including cardiac monitoring, blood pressure, respirations rate and pulse oximetry.
F. Bed in lowest position, side rails up and call light in place.
G. Establish baseline LOC of the patient.
Which symptoms would you teach your patients to report immediately to the RN prior to receiving a peripheral or spinal block? (Circle one)
A. Dry mouth, mild dehydration and nausea.
B. Tinnitus, shivering, feelings of excitement or agitation.
C. Sensation of small poke and burn during initial needle insertion.
D. Report loss of temperature sensation, loss of pain perception and loss of movement.
Which group of signs or symptoms are indications that a LAST event is occurring? (Circle one)
A. Respiratory acidosis, sudden heat production and skeletal muscle rigidity.
B. Complaint of metallic taste in mouth, tinnitus, slurred speech, cardiovascular excitement.
C. High fever, headache, backache, malaise and vomiting.
D. Descending flaccid paralysis with bulbar palsies, clear sensorium and no fever.
Lipids are located in the Pyxis: under keywords, "_____" or "_____" and the Blue Anesthesia cart, top drawer under "_____." (Fill in the blank.)
On a scale of 1-10, with 1 being not comfortable and 10 being very comfortable, what would you rate your comfort level of your role during a LAST event? (Circle one)
1 2 3 4 5 6 7 8 9 10

LAST, local anesthetic systemic toxicity; LOC, level of consciousness; PACU, postanesthesia care unit.

total score (percentage of questions answered correctly) was completed by staff from four units (OS, L&D unit, PACU, and OR) before and after attending an educational intervention regarding LAST. Because of the small number of participants and non-normality of the responses, the data are summarized using medians and the interquartile range (responses corresponding to 25th and 75th percentiles). Survey responses are not always paired, that is, some staff members completed the survey at only one of the two time points (before or after attending the intervention). As such, nonparametric two sample *t* tests were run (Wilcoxon exact test). All significance testing was two sided ($\alpha = 0.05$). The SAS software (version 9.4; Cary, NC) was used.

Results

Consistently across all units, nursing staff's comfort level with a LAST event increased following the education interval (Table 2). For all three units, the median posteducation comfort score was 80% and the median posteducation total score was 100%. For the Kootenai Outpatient Surgery (KOS) and PACU unit, all the participants correctly answered all the questions on the posteducation test. The change in comfort scores and total scores from pre-education to posteducation was statistically significant for all units combined as well as for individual units (all *P* values were less than .0001).

Discussion

Before this project, nurses who worked in Pre-Op, PACU, OR, L&D unit, or OS departments had not received formal education or training regarding the recognition and treatment of a LAST event. In additional, a formal emergency protocol and competency specifically regarding PNB did not exist. As a

Table 2. Change in Comfort and Total Scores Following LAST Education Intervention

		Pre-education		Posteducation		
Unit	**Metric**	**n**	**Median (IQR)**	**n**	**Median (IQR)**	***P* Value***
OS	Comfort	12	3.5 (2-3)	12	8.0 (8-8)	< .0001
	Total score†	12	80.0 (60-80)	12	100.0 (100-100)	< .0001
L&D unit	Comfort	15	3.0 (2-5)	13	8.0 (9-9)	< .0001
	Total score	15	60.0 (20-80)	13	100.0 (80-100)	< .0001
PACU	Comfort	35	3.0 (2-5)	21	8.0 (7-9)	< .0001
	Total score	36	60.0 (40-80)	21	100.0 (100-100)	< .0001
OR	Comfort	10	4.5 (2-5)	10	8.0 (7-9)	< .0001
	Total score	10	66.0 (60-80)	10	100.0 (100-100)	< .0001
All units	Comfort	72	3.0 (2-5)	70	8.0 (7-10)	< .0001
	Total score	73	60.0 (40-80)	70	100.0 (100-100)	< .0001

LAST, local anesthetic systemic toxicity; L&D, labor and delivery; OS, outpatient services; OR, operating room; PACU, postanesthesia care unit; IQR, interquartile range (25th to 75th percentile).

*P value corresponding to the nonparametric two-sample t test (Wilcoxon exact test).

†Total score is the percentage of the questions answered correctly.

result of this project, the creation of a formal PNB protocol and a block specific competency were written and implemented into nursing practice.

The formal PNB policy states, the patient will have continuous cardiac monitoring until the patient goes back to the OR or meets criteria for transfer or is discharged home. Vital signs are obtained every 5 minutes during the block procedure and every 15 minutes until the patient goes back to the OR or as appropriate for the level of care.

Strategies were identified in the prevention of LAST and nurses were educated on best practice including facilitating patient safety with a thorough preprocedural checklist and assessment, time-out, consent verification, continuous 1:1 monitoring, documentation, and availability of emergency equipment availability.[1,4,9] Allergies and any previous adverse reactions to blocking agents were addressed and verbalized to the anesthesia provider, before the procedure.[2]

Techniques regarding anesthesia administration were also reviewed, and an emphasis was placed on slow injection with gentle aspiration every 5 mL, use of ultrasound with observance of spread on the ultrasound monitor, continuous patient assessment and the early recognition, and rapid treatment of symptoms of toxicity.[2,7,12] Continuous cardiac monitoring and documentation of cardiac rate and rhythm, blood pressure, respiration rate, oxygen saturation, and neurologic monitoring were continuously assessed and documented by nurses assisting with block procedures.[2,4,5,12]

Frequent communication with the patient can provide information to the nurse about early acute symptoms of toxicity. Nurses who work in Pre-Op, PACU, OS, and L&D unit were taught to educate their patients on recognizing the signs of symptoms of a LAST event before the administration of a block and to speak up if adverse symptoms occur (ie, ringing in ears, metallic taste in mouth). The OR circulating nurses were taught to continue their baseline level of consciousness assessment and communication while transporting their patients from Pre-Op to the OR.

Because LAST events are rare and serious it is critical that education is provided to staff so that competency cannot only be gained but maintained. Annual competency and education review is currently being built in the form of an electronic online education module for nursing staff who work in departments where PNBs are routinely performed.

Limitations

This EBP project was implemented at one regional hospital within the selected units and one outpatient ambulatory surgery center setting. Therefore, the conclusion cannot be made that all nurses that

work in areas where block procedures are performed have the same level of knowledge and comfort with LAST events. The questions used in this project were developed by the authors and have not been evaluated within any other groups. This project did not evaluate long-term retention of knowledge.

Conclusions

This project identified that nurses do need dedicated education regarding LAST events. Although the incidence of LAST is rare, having a knowledge base that includes basic pathophysiology, signs and symptom recognition, and treatment methods has the potential to save the life of a patient experiencing a LAST event. Didactic education did improve the nurses' postscores; however, the question remains with the infrequency of LAST events will the knowledge be retained. This project was the first step to improve nurses' knowledge and raise awareness of the LAST event through a simple yet effective nurse led evidence-based intervention. The development of annual LAST simulations and educational in-service programs may provide reinforcement about the signs, symptoms, and treatment.

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