



The Knowledge, Perception, and Attitudes of Residents Working in Intensive Care Unit About Local Anesthetic Systemic Toxicity: A University Hospital Data

© Mehmet Nuri Yakar¹, © Mehmet Meriç Çoban², © Doğukan Şenberber³, © Mehmet Celal Öztürk¹, © Murat Küçük⁴, © Bişar Ergün⁴, © Ali Necati Gökmen¹

¹Dokuz Eylül University Faculty of Medicine, Department of Anesthesiology and Reanimation, Division of Intensive Care, İzmir, Turkey

²Dokuz Eylül University Faculty of Medicine, Department of Internal Medicine, İzmir, Turkey

³Dokuz Eylül University Faculty of Medicine, Department of Anesthesiology and Reanimation, İzmir, Turkey

⁴Dokuz Eylül University Faculty of Medicine, Department of Internal Medicine, Division of Intensive Care, İzmir, Turkey

Abstract

Objective: The primary aim of this study is to evaluate the knowledge, perception, and attitudes of residents working in intensive care units from different disciplines about local anesthetic systemic toxicity (LAST).

Methods: Residents from anesthesiology and reanimation, internal medicine, cardiovascular surgery, thoracic surgery, and cardiology were enrolled in the study after they obtained written informed consent. The participants answered 41 questions about local anesthetics and LAST.

Results: A total of 148 residents [median age 28 (24-44) years, 56.1% male] were enrolled in the study. Of them, 34.5% stated that they received education on local anesthetics, and 22.3% declared that their education on this subject was sufficient. The most used methods for preventing LAST were the use of appropriate doses (74.3%), pre-injection aspiration (65.5%), and monitoring (63.5%). Of the participants, 59.5% indicated that they did not know whether there was 20% lipid-emulsion in their hospital and 72.3% in their unit. The participants had a low knowledge rate of early and late symptoms of LAST. They also gave rarely correct answers about the loading, maintaining, and maximum doses of 20% lipid emulsion. The basic principles of cardiopulmonary resuscitation in LAST were generally well known by participants, but the optimal length of the follow-up duration after convulsion and cardiovascular instability was not.

Conclusion: Prevention, recognition, management of the LAST, and the following of the patients with LAST are essential for patient safety in the intensive care unit. Residents working in intensive care units should be educated about LAST regardless of their branch.

Keywords: Medical education, local anesthetics, toxicity, intravenous lipid emulsions

INTRODUCTION

Local anesthetics provide a loss of sensation on the injection site without causing the loss of consciousness and alteration in the central control of vital functions (1). However, local anesthetics may cause local responses, including irritation on the injection site, cellular toxicity, temporary neurological symptoms, and

systemic reactions such as anaphylaxis, methemoglobinemia, and local anesthetic systemic toxicity (LAST) (2).

The use of high doses of local anesthetics increases the risk of achieving toxic plasma levels. Accidental intravascular injection may also cause the LAST (2). In recent decades, using local anesthetics to provide regional analgesia in patients with trauma



Address for Correspondence: Mehmet Nuri Yakar, Dokuz Eylül University Faculty of Medicine, Department of Anesthesiology and Reanimation, Division of Intensive Care, İzmir, Turkey

Phone: +90 232 412 22 22 **E-mail:** dr.nuriyakar@gmail.com **ORCID ID:** orcid.org/0000-0002-3542-3906

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or who underwent an operation has become more common in intensive care units (3,4). However, the data related to the LAST in critically ill patients is limited. In regional anesthesia procedures, the LAST rate was 9.8 (5) and 8.7 (6) per 10.000 peripheral nerve blocks using conventional methods and under ultrasonography guidance, respectively. LAST is a life-threatening complication of local anesthetics, and prevention, recognition, diagnosis, and management of this entity by the residents working in intensive care units are essential. Previous studies revealed residents' knowledge about the LAST (7-9), but the data of residents from different disciplines working in intensive care units remain unclear.

In this prospective single-center study, we presented the knowledge, perception, and attitudes of the residents from internal medicine, anesthesiology and reanimation, cardiovascular surgery, thoracic surgery, and cardiology about the LAST.

METHODS

Study Design

The study was approved by the Local Ethics Committee of Dokuz Eylul University (date: 27.10.2021 and number: 2021/30-06) and conducted in Anesthesiology and Reanimation, Internal Medicine, Cardiovascular Surgery, Thoracic Surgery, and Cardiology Critical Care Units of Dokuz Eylul University Hospital between 01 and 30 November 2021, following the ethical standards of the revised version of the Helsinki Declaration in 2013. Written informed consent was obtained from each participant, and they were asked to answer a survey consisting of 41 questions. Five questions in the questionnaire were about the participants' demographic data and medical disciplines; twelve were about local anesthetics practices; and twenty-four were about participants' knowledge, perception, and attitudes about LAST.

Selection of Participants

Residents training in the disciplines of Anesthesiology and Reanimation, Internal Medicine, Cardiovascular Surgery, Thoracic Surgery, and Cardiology at Dokuz Eylul University, Faculty of Medicine, were enrolled in the study. Graduated residents or not previously worked in intensive care units were excluded from the study.

Variables

Demographic data (age, sex) and properties of the participants' professions (discipline, experience, duration of residency) were recorded. The participants were asked whether they received

formal education on local anesthetics and LAST during residency and how they felt about their knowledge about these issues. Local anesthetic practices (frequency, preferred administration route and local anesthetic preferences), precautions to reduce the LAST risk, the local anesthetics' toxic doses, experiences about the LAST and knowledge about 20% lipid solution were investigated. Participants were also asked whether they knew the presence of 20% lipid emulsion in the hospital and their departments. Additionally, early, and late symptoms of the LAST, conditions needed reduction in local anesthetic doses, LAST treatment, and follow-up protocols were queried. General information about LAST in the questionnaire was prepared according to a previous study (2). LAST treatment and follow-up standards were drafted according to the recommendations in the LAST checklist of the American Society for Regional Anesthesia and Pain Medicine (10).

Outcomes

The primary aim of the study is to evaluate the knowledge, perception, and attitudes of residents from different disciplines (anesthesiology and reanimation, internal medicine, cardiovascular surgery, thoracic surgery and cardiology) about the LAST.

Statistical Analysis

The statistical analysis was performed using the SPSS statistical analysis software (version 24.0; IBM, Armonk, NY, USA). The distribution of the data was analyzed using the Shapiro-Wilk test. Categorical variables were presented as number (n) and percentage (%). Normally, distributed continuous variables were expressed as mean \pm standard deviation, and non-normally distributed variables as median (minimum-maximum). In the statistical analysis, uni- or multivariate analyzes to compare the groups were not needed.

RESULTS

A totally 148 residents [median age 28 (24-44) years, 56.1% male] were included in the study (Table 1). Departments of the participants were distributed as internal medicine (50.0%), anaesthesiology and reanimation (37.8%), cardiovascular surgery (4.7%), thoracic surgery (4.7%), and cardiology (2.7%). The participants' median training duration in their disciplines was 3 (1-7) years.

Of them, 51 (34.5%) stated receiving a formal education about local anesthetics and LAST during residency (Table 2). Only 33 residents (22.3%) expressed that their knowledge about local anesthetics was sufficient. However, 47 (31.8%) residents stated that they knew the toxic doses of local anesthetics,

and 38 (25.7%) participants routinely checked the maximum doses of local anesthetics before the interventions. Only 17 (11.5%) participants had experienced the LAST before. The local anesthetic usage frequency of the participants was distributed as a few in a week (29.7%), every day (22.3%), and a few in a month (18.2%). The most frequently preferred local anesthetics were lidocaine and prilocaine, with a rate of 75.0%. The most frequent administration routes of local anesthetics were subcutaneous (77.0%), intravenous (49.3%), and intrathecal or epidural (36.5%).

The participants' most common LAST prevention method was using an appropriate dose of local anesthetics, with a rate of 74.3%. Aspiration before injection (65.5%), monitorization (63.5%), use of a test dose (60.4%), and incrementally injection (42.6%) were the following prevention methods. Ultrasonography guidance with a rate of 27.7% was less frequent than the other prevention methods. Of all participants, 61 (41.2%) stated that they had knowledge of about 20% lipid emulsion, but 88 (59.5%) in the hospital and 107 (72.3%) in their departments did not know whether the presence of 20% lipid emulsion. Additionally, 8 (5.4%) participants stated the absence of 20% lipid emulsion in the hospital though it was present. Of them, 12 (8.1%) participants expressed no presence of 20% lipid emulsion in their units.

The early and late symptoms of the LAST were not known by 56 (37.8%) and 44 (29.7%) participants, respectively (Table 3). The most known early period symptoms were perioral numbness (41.2%), metallic taste (38.5%), dizziness (29.7%), tinnitus (27.7%), and arrhythmia (27.0%). Cardiac arrest, with a rate of 54.1%, was the most stated late-period complication. Respiratory depression (45.3%), convulsion (45.3%), arrhythmia (41.9%), and atrioventricular block (40.5%) were the other most known late symptoms of the LAST. Most of the participants (93.2%)

Table 1. Demographic data and professional characteristics of the participants

Age, years	28 (24-44)
Sex, male	83 (56.1)
Professional experience, years	4 (1-23)
Discipline	
Internal medicine	74 (50.0)
Anaesthesiology and reanimation	56 (37.8)
Thoracic surgery	7 (4.7)
Cardiovascular surgery	7 (4.7)
Cardiology	4 (2.7)
Length of residency duration, years	3 (1-7)
All values are expressed as n (%) or median (minimum-maximum)	

Table 2. Local anesthetic practices and experiences of the participants

I had a formal education on LA	51 (34.5)	Most frequently preferred LAs	
My knowledge about LA is sufficient	33 (22.3)	Lidocaine	111 (75.0)
I had a formal education on the LAST	41 (27.7)	Prilocaine	111 (75.0)
I have experienced the LAST before	17 (11.5)	Bupivacaine	80 (54.1)
Toxic dose of LAs		Methods for preventing the LAST	
I don't know	63 (42.6)	Use of an appropriate dose	110 (74.3)
I know	47 (31.8)	Aspiration before injection	97 (65.5)
I check it before administration	38 (25.7)	Monitorization	94 (63.5)
Frequency of LA use		Incrementally injection	63 (42.6)
A few a week	44 (29.7)	Use of a test dose	45 (60.4)
Every day	33 (22.3)	USG guidance	41 (27.7)
A few a month	27 (18.2)	Other	7 (4.7)
Once a month	16 (10.8)	I know about 20% LE	61 (41.2)
A few a year	13 (8.8)	Whether 20% LE is present in the hospital	
Once a week	12 (8.1)	I don't know	88(59.5)
LA administration routes		Present	52 (35.1)
Subcutaneous	114 (77.0)	Absent	8 (5.4)
Intravenous	73 (49.3)	Whether 20% LE is present in my department	
Epidural/intrathecal	54 (36.5)	I don't know	107 (72.3)
Intramuscular	37 (25.0)	Present	29 (19.6)
Intranasal	6 (4.1)	Absent	12 (8.1)
All values are expressed as n (%) or median (minimum-maximum). LA, Local anesthetic, LAST: Local anesthetic systemic toxicity, USG: Ultrasonography, 20% LE: 20% lipid emulsion			

knew that the early period symptoms of the LAST might not occur. At least more than half of the participants knew the obligation to use of lower doses of local anesthetics in patients

with kidney or liver failure, pregnancy, the elderly, and in infected surgical sites. Of the participants, 44 (29.7%) and 41 (27.7%) stated that they knew the 20% lipid emulsion loading

Early symptoms of LAST		20% LE maintaining dose duration	
I don't know	56 (37.8)	I know	39 (26.4)
Perioral drowsiness	61 (41.2)	I don't know	108 (73.7)
Metallic taste	57 (38.5)	20% LE maintaining dose duration	
Dysarthria	35 (23.6)	Rate of wrong answers	13 (8.8)
Hypertension	14 (9.5)	Rate of correct answers	26 (17.6)
Dizziness	44 (29.7)	20% LE maximum dose	
Muscle twitching	26 (17.6)	I know	37 (25.0)
Arrhythmia	40 (27.0)	I don't know	111 (75.0)
Tinnitus	41 (27.7)	20% LE maximum dose	
Tachycardia	31 (20.9)	Rate of wrong answers	7 (4.7)
Confusion	23 (15.5)	Rate of correct answers	30 (20.3)
Tremor	14 (9.5)	During LAST	
Late symptoms of LAST		The ECMO team should be informed	119 (80.4)
I don't know	44 (29.7)	The CPR duration may be longer than expected	122 (82.4)
AV block	60 (40.5)	Propofol is not the first choice for convulsions	97 (65.5)
Hypotension	50 (33.8)	Avoid from lidokain administration	121 (81.8)
Convulsion	67 (45.3)	Avoid from beta -blocker use	73 (49.3)
Arrhythmia	62 (41.9)	Amiodarone is the first-choice anti-arrhythmic agent	98 (66.2)
Respiratory depression	67 (45.3)	Avoids from calcium channel blockers	67 (45.3)
Cardiac arrest	80 (54.1)	Avoid from vasopressin use	88 (59.5)
Coma	59 (39.9)	The epinephrine dose should be reduced	118 (79.7)
Loading dose of 20% LE		Other properties of LAST	
I know	44 (29.7)	Early symptoms may not occur	138 (93.2)
I don't know	104 (70.3)	The dose should be reduced in the infected sites	68 (66.2)
Loading dose of 20% LE		The dose should be reduced during renal failure	100 (67.6)
Rate of wrong answers	6 (4.1)	The dose should be reduced during hepatic failure	119 (80.4)
Rate of correct answers	38 (25.7)	The dose should be reduced in the elderly	124 (83.8)
20% LE loading dose duration		The dose should be reduced during pregnancy	100 (67.6)
I know	43 (29.1)	Follow-up duration after seizures	
I don't know	104 (70.3)	Rate of correct answers	28 (18.9)
20% LE loading dose duration		Rate of wrong answers	91 (61.5)
Rate of wrong answers	14 (9.5)	No answer	29 (19.6)
Rate of correct answers	29 (19.6)	Follow-up duration after cardiac instability	
Maintenance dose of 20% LE		Rate of correct answers	31 (20.9)
I know	41 (27.7)	Rate of wrong answers	86 (58.1)
I don't know	105 (70.9)	No answer	31 (20.9)
Maintenance dose of 20% LE			
Rate of wrong answers	10 (6.8)		
Rate of correct answers	31 (20.9)		

All values are expressed as n (%) or median (minimum-maximum). LAST: Local anesthetic systemic toxicity, AV block: Atrioventricular block, 20% LE: 20% lipid emulsion, ECMO: Extracorporeal membrane oxygenation, CPR: Cardiopulmonary resuscitation

and maintenance doses, respectively. However, 38 (25.7%) and 31 (20.9%) participants correctly knew the loading and maintenance doses, respectively. The rate of participants who stated that they knew the administration duration of 20% lipid emulsion loading and maintenance doses were 43 (29.1%) and 39 (26.4%), respectively. However, only 29 (19.6%) and 26 (17.6%) participants correctly knew loading and maintaining duration, respectively. Only 10 (17.6%) participants knew the maximum dose of 20% lipid emulsion correctly. Most of the participants stated that the duration of cardiopulmonary resuscitation (CPR) might be longer than expected (82.4%), lidocaine should be avoided as an anti-arrhythmic agent (81.8%), the extracorporeal membrane oxygenation (ECMO) team should be informed in the LAST management (80.4%), and the epinephrine dose should be reduced during CPR (79.7%). Additionally, more than half of the participants knew that amiodarone is the first choice to treat arrhythmias in the LAST (66.2%), propofol should not be preferred to control convulsions (65.5%), and vasopressin administration should be avoided (59.5%). However, less than half of the participants stated that using beta-blockers (49.3%) and calcium channel blockers (45.3%) should be avoided. The proportions of the participants who correctly knew the length of follow-up duration after cardiovascular instability and seizure were 31 (20.9%) and 28 (18.9%), respectively.

DISCUSSION

In this study, we evaluated the knowledge, perception, and attitudes of the residents working in intensive care units from different disciplines about the LAST. Only one-third of the participants received formal education on local anesthetics and the LAST during the residency, and one-fifth felt their knowledge about these issues was sufficient. Most participants did not know whether the 20% lipid emulsion was present in the hospital or units where they worked. Additionally, the participants did not have sufficient information about the loading, maintenance, and maximum doses of 20% lipid emulsion therapy and the length of administration durations. Although the participants knew the conditions that the local anesthetic dosage should be reduced, one-third of the participants did not correctly know the toxic doses of the local anesthetics. Early and late symptoms of the LAST were known by less than half of the participants. Conversely, the participants' knowledge about anti-arrhythmic agents and managing CPR in the LAST was sufficient. However, the length of the follow-up duration in patients with cardiovascular instability or seizure was not commonly known by the participants.

Prevention of the LAST is essential, as well as its manage. Local anesthetics should be administered under monitorization

standards, including electrocardiography, pulse oximetry, and non-invasive tension measurement (11). The dose of local anesthetics should be planned before the procedures, avoided high doses, and administered in places that consist of CPR equipment. Additionally, frequent aspiration prevents intravascular injections by mistake, and slowly injections reduce the risk of achieving peak plasma concentration of the local anesthetics. Using a test dose may determine the migration of the neuraxial catheters (2). The ultrasonography-guided injection is a method to prevent LAST development (12). This method reduces the LAST risk by reducing local anesthetic consumption (2). In this study, most of the participants used the method of frequent aspiration before injection and provided monitorization standards. Most participants stated that they use the appropriate doses of local anesthetics. However, only one-third of the participants knew the toxic doses of local anesthetics, but a quarter of the participants checked the toxic doses before administration. Incremental injection was another standard method to prevent LAST, but the use of ultrasonography guidance was limited.

The Association of Anaesthetists of Great Britain and Ireland divided into four parts of LAST management such as (I) recognition, (II) immediately management, (III) treatment, and (IV) follow-up (13). Training health professionals on the LAST ensures patient safety by recognizing and immediate management of the LAST (2). Notably, the participants had insufficient knowledge of early LAST symptoms in this study. However, LAST is included in the formal education programs of anesthesiology and reanimation (14) and cardiovascular surgery (15) departments in Turkey, but not in internal medicine (16), cardiology (17), and thoracic surgery (18).

The LAST treatment depends on 20% lipid emulsion therapy (13,19). Different mechanisms have defined how 20% lipid emulsion affects the treatment of the LAST. The 20% lipid emulsion allocates a lipid compartment within the vascular compartment and provides local anesthetics to be drawn from their receptors to this compartment, but this effect may be limited (20). Local anesthetics block fatty acid metabolism in the heart; 20% lipid emulsion provides the substrate for cardiac metabolism and prevents the increase in mitochondrial inner membrane permeability that causes cell death (21). In addition, 20% lipid emulsion competitively inhibits the binding of local anesthetics to cardiac sodium channels (22). In this study, most participants incorrectly answered the questions related to the loading and maintenance doses of 20% lipid emulsion and the loading and maintaining durations.

High doses of 20% lipid emulsion may cause hypertriglyceridemia, acute pancreatitis, lipid embolism, acute kidney injury, acute lung injury, increased risk of infections, and cardiac arrest (23). Notably, only one-fifth of the participants knew the maximum dose of 20% lipid emulsion.

The CPR procedure has some differences in patients suffering cardiac arrest due to the LAST. The CPR duration may be longer than expected (13). ECMO is an alternative to provide survival for the patients until local anesthetics are eliminated. In patients with LAST, lidocaine and many other anti-arrhythmic agents should be avoided during CPR. The dose of norepinephrine should be reduced (10). In this study, participants sufficiently knew these abovementioned issues. The American Society of Regional Anesthesia and Pain Medicine recommends at least 2 h follow-up after seizures and 4-6 h after cardiovascular instability in patients with LAST (10). Most of the participants in this study incorrectly answered questions related to the length of follow-up duration in patients with LAST.

Study Limitations

This study had some limitations. The residents working intensive care units from different departments, such as Chest Diseases or Neurology, were excluded from the study. The results of this prospective single-center survey study could not be generalized and should be supported by novel studies with large sample sizes.

CONCLUSION

Local anesthetics are frequently used in intensive care units. LAST is one of the possible complications that also occur in intensive care units. Recognizing, preventing, and managing the LAST in critical patients are essential. Local anesthetics should be used under baseline standards, including monitorization, appropriate dosage, and ultrasonography guidance. To recognize and immediately treat the LAST, residents working in intensive care units from different disciplines should receive formal education on local anesthetics and LAST, regardless of the branch.

Ethics

Ethics Committee Approval: The study was approved by the Local Ethics Committee of Dokuz Eylul University (date: 27.10.2021 and number: 2021/30-06) and conducted in Anesthesiology and Reanimation, Internal Medicine, Cardiovascular Surgery, Thoracic Surgery, and Cardiology Critical Care Units of Dokuz Eylul University Hospital between 01 and 30 November 2021, following the ethical standards of the revised version of Helsinki Declaration in 2013.

Informed Consent: Written informed consent was obtained.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: M.N.Y., M.M.Ç., D.Ş., M.C.Ö., M.K., B.E., A.N.G., Design: M.N.Y., M.M.Ç., D.Ş., M.C.Ö., M.K., B.E., A.N.G., Data Collection or Processing: M.N.Y., M.M.Ç., D.Ş., M.C.Ö., M.K., B.E., A.N.G., Analysis or Interpretation: M.N.Y., M.M.Ç., D.Ş., M.C.Ö., M.K., B.E., A.N.G., Literature Search: M.N.Y., M.M.Ç., M.C.Ö., B.E., Writing: M.N.Y., A.N.G.

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