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ORIGINAL RESEARCH

The awareness of local anaesthetic systemic toxicity among registrars from surgical disciplines at a tertiary hospital, South Africa

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Background: The use of local anaesthetic (LA) agents has transformed medicine and enhanced the development of surgery. Local anaesthetic systemic toxicity (LAST) is a life-threatening incident that may occur following administration of LA agents. A sound knowledge of LAST and its treatment is important for patient safety. Surveys done at many hospitals demonstrated a lack of knowledge regarding LAST and the management thereof by non-anaesthetists. The aim of this study was to assess knowledge and awareness of LAST among registrars from various surgical disciplines at Tygerberg Academic Hospital (TBH).

Methods: We performed a descriptive cross-sectional study. A web-based questionnaire was sent to 201 registrars from different surgical disciplines at TBH. The results were analysed using descriptive statistics.

Results: We received 102 responses (response rate 51%). The mean knowledge score was 67.9%, standard deviation (SD) 15.2, with a range of 20–100%. Only 18.6% of the registrars had encountered a case of LAST in their practice. Approximately 50% of the registrars knew the maximum recommended dose of bupivacaine and 54% indicated that they had previous training in the management of LAST. Only 40.2% of the registrars knew the specific treatment of LAST. The knowledge score was higher for those who had previous training in the management of LAST with a mean (SD) of 73% (13.7). A statistical difference (p-value = 0.045) between the years of training and the knowledge about LAST was demonstrated.

Conclusion: Registrars' knowledge and awareness of LAST and safe use of LA agents were concerning. This was shown to improve with years of registrar training as well as with previous training specifically about LAST. A lack of knowledge was found in identifying lipid emulsion as the specific treatment of LAST. These factors can be improved by training and awareness campaigns.

Keywords: local anaesthetic, lipid emulsion, local anaesthetic systemic toxicity awareness

Introduction

The local anaesthetic (LA) effect of cocaine was discovered in the late 1800s and transformed the scope of medical practice.[1] LA use by various healthcare professionals from various disciplines has increased over the years. Worldwide, approximately 6 million people are injected with LA agents each day.[2] Many surgical procedures are performed using LA agents only, some of which are performed safely in remote settings outside a formal theatre facility.

LA agents can be used safely and toxicity can be minimised by applying basic safe practices, including patient assessment with focus on coexisting medical conditions, injection technique, correct dose calculation and LA choice.[3,4] This includes consideration for patient- and drug-related factors influencing the pharmacokinetics and pharmacodynamics of LA agents that may affect individualised calculations of the volume and concentration for blocks, balancing the risk of block failure (inadequate dose) and adverse effects from excessive dosing.[5]

Local anaesthetic systemic toxicity (LAST) is a life-threatening adverse event, mostly occurring due to accidental intravascular injections of LA agents, excessive dosage and pathological states which are more prone to toxicity, for example, liver failure.[6] There are wide variations in the reported incidences of LAST, and a recent analysis of two large databases estimated an incidence of 1–2 cases per 1 000 nerve blocks.[7] However, it is widely recognised as often misdiagnosed and underreported.[7,8]

As early as 1979, Albright increased general awareness among clinicians about the hazards of LAST.[9] Long-acting LA agents have the potential to cause severe cardiac toxicity due to its lipophilic nature.[9] El-Boghdadly et al.[10] described mechanisms of LAST as multifactorial, with diverse cellular effects in both the central nervous system (CNS) and the cardiovascular system (CVS), CNS toxicity being more common while refractory cardiac arrest has a higher mortality risk.

Appreciation for the severity of a toxic reaction and the ability to recognise and manage LAST appropriately are vital. It is not uncommon for clinicians to confuse LAST with anaphylaxis.[11] Thorough knowledge of the signs and symptoms of LAST aids a rapid diagnosis, and is a key determinant in instituting proper treatment and influencing patient outcomes.[7] Further determinants include appropriate training, the availability of resuscitation equipment and the use of lipid emulsion as a specific treatment.[12]

In 1998, Gitman et al.[8] demonstrated that intravenous lipid emulsion (ILE) improved outcomes in rodents following bupivacaine-induced cardiac arrest, and the first successful human resuscitations with ILE occurred in 2006.[13,14] Since then, numerous adult and paediatric case reports indicate the efficacy

of ILE use for the treatment of LAST.[15] Both the Association of Anaesthetists of Great Britain and Ireland (AAGBI) and the American Society of Regional Anesthesia and Pain Medicine (ASRA) include ILE as the specific treatment of LAST in their guidelines on the management of LAST.[16,17]

Multiple surveys and studies, at all levels of care, demonstrated a lack of knowledge about LAST, and the management thereof, among non-anaesthetists.[15,18-24] Several studies comparing the knowledge of non-anaesthetists versus anaesthetists also confirmed a lack of knowledge in the former group.[15,25,26] This obvious disparity exists as anaesthesia practitioners have more experience using LA agents, and the pharmacology and pathophysiology are integral parts of anaesthesiology curriculums.

Despite the publication of the AAGBI guidelines for the management of LAST in 2007, surveys from the United Kingdom (UK) confirmed the lack of knowledge regarding the maximum toxic doses of LA agents as well as the use of lipid emulsions as a specific treatment option in LAST, among various groups of clinicians, ranging from junior emergency doctors and surgical registrars to nursing personnel and non-anaesthetist specialists.[15,24,25] Two subsequent UK studies, among a group of non-anaesthetists and plastic surgeons, demonstrated a paucity in knowledge and inaccuracies in LA dose calculations, and a lack of knowledge about LAST and ILE as a treatment option.[23,26] A study among UK dermatologists found similar results.[19]

In 2013, a survey-based study from a tertiary hospital in India included 200 postgraduate residents of various non-anaesthetic specialties, and 93% of the residents were unaware of the toxic dose of bupivacaine. However, 81% of the residents could identify the signs and symptoms of cardiotoxicity while only 2% of the residents identified ILE as the specific treatment of LAST.[22] A 2017 study evaluating Turkish ophthalmologists on LAST determined that 65% of the respondents knew about the use of ILE.[18] Another Turkish study in 2018, evaluating dentists, determined that two-thirds of dentists were unaware about ILE as treatment and only 1.5% of the participants knew how to give ILE.[20]

There is presently no published data from South Africa (SA). The primary aim of our study was to assess the level of awareness of LAST among registrars, from multiple surgical disciplines, at our tertiary academic hospital. We wanted to identify the safe or unsafe practices while using LA, the knowledge of early and late signs and symptoms of LAST, as well as knowledge of the role of ILE during the management of LAST.

Methods

A descriptive cross-sectional study was conducted at Tygerberg Academic Hospital (TBH). A web-based questionnaire was created using REDCap® (Research Electronic Data Capture), a secure platform for building and managing online surveys and databases. The questionnaire was prepared following a literature review as well as an expert panel review by six consultant anaesthesiologists. Our study received institutional permission and ethical approval.

The Division for Information Governance at Stellenbosch University (SUN) provided the email addresses of the registrars. Registrars from the following surgical disciplines were included: ophthalmology, obstetrics and gynaecology (O&G), orthopaedic surgery, general surgery, urology, plastic surgery, ear nose and throat (ENT), neurosurgery, emergency medicine and cardiothoracic surgery. A total of 201 registrars were identified at the time of data collection. We excluded anaesthetic registrars and consultants, as well as the various surgical consultants, medical officers, undergraduate students and medical interns.

The study was conducted over a six-week period, May–June 2021. An introductory email serving as informed consent was sent to the registrars. The email contained a link to the questionnaire and explained the rationale of the study and that confidentiality and anonymity of the registrars would be guaranteed. Completing the questionnaire indicated implicit consent (questionnaire completion would take approximately five minutes). Participation was voluntary and each registrar was assigned an anonymous case number. Two reminder emails were sent weekly over a five-week period to those who had not completed the survey. Also, an incentive scheme (funded by the Jan Pretorius SASA grant) in the form of a lucky draw was created to increase the response rate. The questionnaire consisted of 18 questions; one open-ended question, one matrix question and 16 multiple-choice questions (Appendix 1). The data were exported to SPSS version 27.0 (IBM Corp., USA; 2020) and the results were analysed using descriptive statistics, frequencies, percentages, means, standard deviation (SD) and analysis of variance (ANOVA) tests.

The questionnaire consisted of eight knowledge-based questions (questions 11–18) comprising a total of 20 knowledge items. The registrars scored a point for each correct answer for questions 11–13 and 16–17. They could score a maximum of five points for questions 14 and 15, as these questions had three correct and two incorrect answers; checking the correct answers would yield three points and unchecking both wrong answers would yield two points. Question 18 could yield a maximum of five points. A knowledge score was calculated by adding up the correct responses to each of the 20 knowledge items and was expressed as a percentage.

Results

A response rate of 51% (102/201) was achieved. The majority of the registrars were aged between 30 and 34 years and 62% were male. Most registrars were from orthopaedic surgery (22.4%) followed by equal numbers from O&G and general surgery (both 19.4%). Table I depicts the demographics of the registrars who responded. The highest percentage of registrars were in their second to fourth year of their training (52.5%), 20.2% of the registrars had less than one year training, 15.2% had 1–2 years of training while 12.1% had more than five years of training.

Half of the registrars indicated that they used LA agents 1–2 times per week in their usual practice and 40% used it multiple times on a workday. In addition, 93% performed an aspiration test before injecting LA agents. Only 18.6% had encountered a case of LAST in their practice and approximately 7% indicated that they did not know whether they had come across this complication.

Table I: Registrar demographics and clinical discipline

	Registrar demographics	Count	Percentage (%)
Age (years)	25–29	7	6.9
	30–34	56	55.4
	35–40	35	34.7
	> 40	3	3
Gender	Male	62	62
	Female	38	38
Clinical discipline	Cardiothoracic surgery	3	3.1
	Emergency medicine	12	12.2
	Ear, nose and throat	5	5.1
	Neurosurgery	4	4.1
	General surgery	19	19.4
	Obstetrics & gynaecology	19	19.4
	Ophthalmology	6	6.1
	Orthopaedics	22	22.4
	Plastic surgery	1	1
	Urology	7	7.1

Furthermore, 54% of the registrars reported that they had received previous training on the recognition and management of LAST and the most common form of training was during undergraduate medical training (50.9%). The most commonly used LA by registrars was plain lignocaine (68%). In our study, we accepted 3 mg/kg as the maximum dose for plain lignocaine, 7 mg/kg as the maximum dose for lignocaine and adrenaline, and 2 mg/kg as the maximum dose for bupivacaine.[27] Regarding the correct maximum doses of LA agents, 41.4% of the registrars knew the maximum dose of lignocaine (response rate of 97.1%, three missing responses), 64.6% of the registrars knew the maximum dose of lignocaine with adrenaline (response rate of 97.1%) and 50.5% of the registrars knew the maximum dose of bupivacaine (response rate of 96.1%, four missing responses). Only 40.2% of the registrars knew that ILE is the specific treatment of LAST.

Overall, the mean (SD) knowledge score was 67.9% (15.2) (range 20–100%). A knowledge score greater than 50% was achieved by 87.3% of the registrars and a knowledge score of greater than 75% was achieved by 28.4% of the registrars. The knowledge score of those registrars who routinely performed an aspiration test was 69% (SD 13.5). The knowledge score in the registrars who had some form of previous training in LAST was a mean (SD) of 73% (13.7). Only 40.2% of the registrars knew that ILE was the specific treatment of LAST, the overall knowledge in this group was 76.2% (SD 11).

There was no significant statistical difference between the clinical disciplines and knowledge scores ($p = 0.097$). We grouped some disciplines together (ophthalmology, cardiothoracic surgery, ear, nose and throat, plastic surgery, urology and neurosurgery) as those had smaller numbers and we wanted to avoid possible reputational harm while reporting the knowledge component.

There was a statistical difference ($p = 0.045$) between the stage of training of the registrars and their knowledge of LAST (Figure 2). Knowledge scores increased as years of registrar training increased.

Only 17.6% of the registrars were able to correctly identify all the early signs and symptoms of LAST, while 43.1% correctly identified all the late signs and symptoms. Of the registrars, 61% knew that bupivacaine is associated with refractory cardiac symptoms.

The results in Figure 3 show which monitoring equipment and safety precautions were deemed important when doing regional blocks with potentially toxic doses. The use of an intravenous

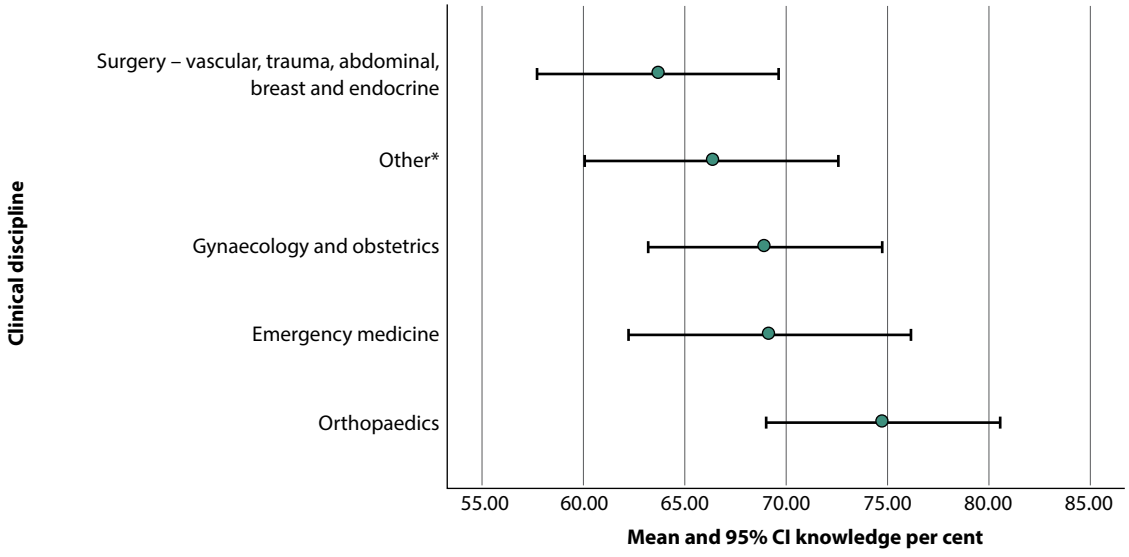

Figure 1: Mean (95% CI) scores of knowledge among different disciplines
** Other includes ophthalmology, cardiothoracic surgery, ear, nose and throat, plastic surgery, urology and neurosurgery*

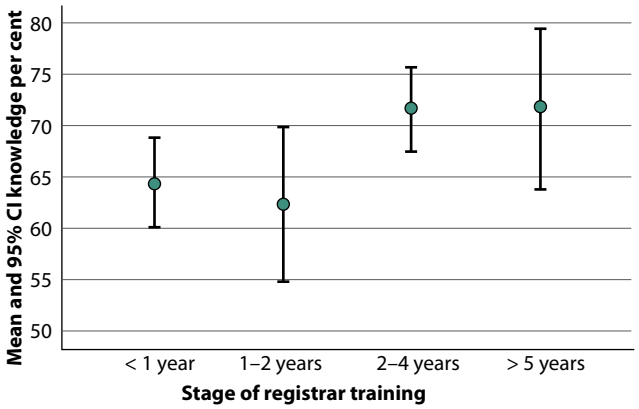

Figure 2: Mean (95% CI) scores of knowledge of different stages of registrar training

cannula was considered essential by 77.5% and desirable by 18% of the registrars. The availability of a resuscitation trolley was essential for 84.3% and desirable by 11% of the registrars. The need for monitors during procedures varied, between 56% and 65% of the registrars deemed one or more monitors essential, while approximately 7–15% thought these were unnecessary. Of the registrars, 46% indicated that all three monitors (electrocardiogram, blood pressure and pulse oximetry) were essential.

Discussion

The response rate of 51% suffers a non-response bias of 49%. The collection of questionnaires was done over a six-week period that did not overlap major holidays or exam periods and occurred between the second and third COVID-19 waves in SA. It was therefore considered an appropriate time to get a reasonable response rate from registrars.

Our study suggested that LA agents are frequently used by registrars, with 40% of the registrars using LA multiple times per day. Approximately 87% of the registrars had a knowledge score greater than 50%, but it is debatable whether this is an appropriate knowledge score on an important drug that can lead to potential and iatrogenic fatal complications. The breakdown of the knowledge-based questions was concerning, as less than half of the registrars (41.4%) knew the maximum recommended dose of lignocaine while this was the most frequently used LA agent, and only half knew the maximum recommended dose of bupivacaine. The difference in knowledge-based questions among the clinical disciplines was not statistically significant.

Using the lowest effective dose of LA is the best recommended method of preventing toxicity.[6,28] Also, several precautions can be taken when performing local and regional blocks, such as performing an aspiration test before injection and incremental injections to prevent inadvertent intravenous administration of LA agents.[3] In this study, it was reassuring that the majority of registrars (93%) indicated that they perform aspiration tests.

Careful monitoring is mandatory to diagnose signs and symptoms of LAST. The AAGBI issued a new guideline in 2021 stating that regional anaesthesia requires minimum monitoring of the heart rate and rhythm, blood pressure and peripheral capillary oxygen saturation prior to the beginning of the procedure and continued for at least 30 minutes after block completion.[29] Our study confirmed that the minimum standard of monitoring was not considered essential when performing blocks that needed high doses of LA agents, with only 46% of the registrars indicating that all three monitoring equipment were essential. In this context, it may be more appropriate for certain cases to be treated in a formal theatre setting. However in practice, it is understandable that many cases have to be done outside of the theatre setting by non-anaesthetic trained

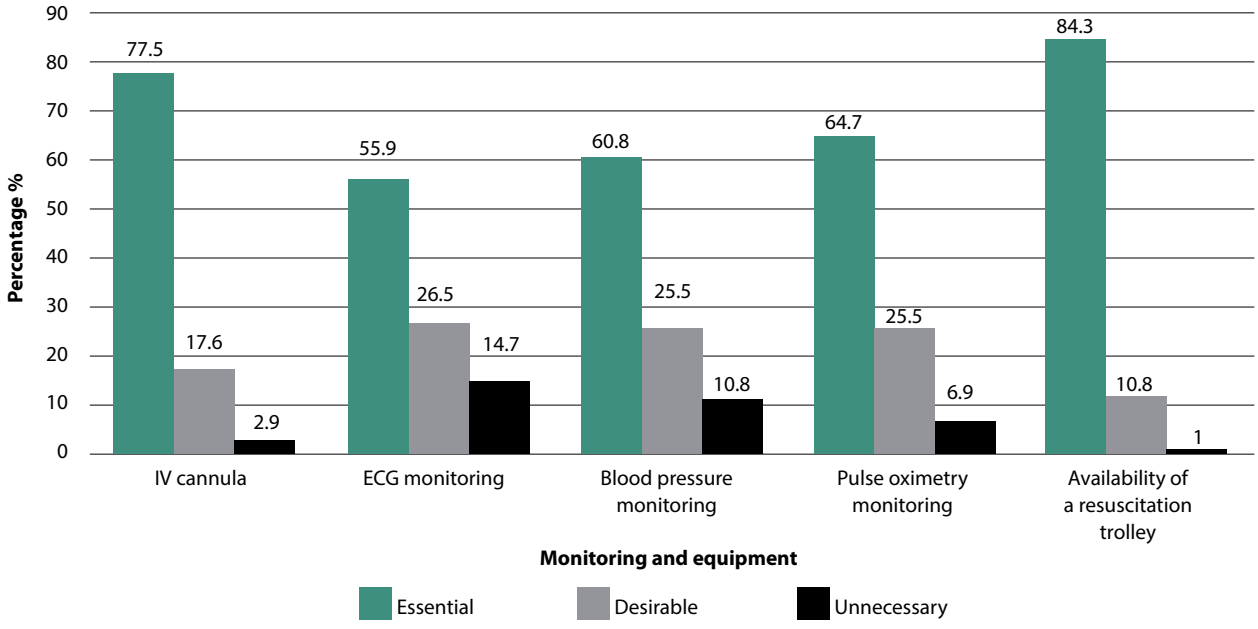

Figure 3: Monitoring equipment and safety precautions that were deemed essential, desirable or unnecessary when using potentially toxic doses of LA agents

personnel due to the pressure on theatre time and necessity to clear busy casualty rooms and wards.

It is particularly concerning that although some registrars could identify a few early signs and symptoms of LAST, only 17.6% were able to correctly identify all three early signs and symptoms. Furthermore, recognition of the late signs and symptoms was not adequate either (only 43% of the registrars recognised all three). It was slightly more reassuring that 61% of the registrars knew that bupivacaine is associated with refractory cardiac symptoms. A reluctance to use minimum accepted monitoring during blocks, together with the inability to recognise the signs and symptoms of LAST, may lead to delays in recognition and effective treatment of LAST.

Not only is the diagnosis of LAST important, but it is also vital to know that ILE is the specific treatment of LAST. The exact location of ILE at each institution should be known. Our study proved that a lack of knowledge exists about ILE being the specific treatment of LAST with close to 60% of the registrars not being aware of this therapeutic option.

Studies report that LAST might be under-recognised and underreported.[7,8] Our study is in line with these findings, as 7% of the registrars did not know whether they had encountered a case and approximately only 19% had experienced LAST in their practice. Of note, the knowledge score was lower among those registrars who had never encountered a case of LAST (mean [SD] of 67.8% [13.6]) and those who did not know whether they had encountered a case (mean [SD] of 67.9% [15.8]) compared to registrars who had experienced an event of LAST in their practice (mean [SD] of 73.4% [13.1]). This suggests that knowledge increases with clinical experience and is confirmed by the results shown in Figure 2, a statistical difference ($p = 0.045$) between the stage of training of the registrars and their knowledge about LAST.

Our study's results are consistent with published literature where non-anaesthetic medical professionals demonstrated a gap in knowledge with regards to the clinical manifestation of LAST and the specific treatment thereof. The next logical step would be a training intervention aimed at non-anaesthesia medical professionals (i.e. nursing and medical personnel) and a follow-up study.

Recommendations

We recommend increased simulation training in the management of LAST, involving surgical registrars, as well as nurses of high-risk specialties, where procedures outside the operating theatre are commonly performed (for example, O&G and emergency medicine), and medical students and interns.

We are eager to either create an institutional guideline or contribute to a national guideline for the management of LAST. This guideline must be easy to follow and adapted for non-anaesthetists while being displayed not only in operating rooms, but also in other procedural areas where patients are treated. The 2016 South African Society of Regional Anaesthesia (SASRA) guidelines for the management of LAST included the 2010 AAGBI guidelines.[30]

Within our institution, we want to ensure that every location where LA agents are routinely used is supplied with basic resuscitation equipment and a clear indication of where to source the nearest ILE. In smaller units, clinics and general practitioners' rooms, we recommend a rescue kit. Such a kit should contain basic airway management tools, benzodiazepine ampoules, syringes, large bore intravenous cannulas, a manual resuscitator, and a printed algorithm for the management of LAST. The overall goal of such measures would be to improve patient safety by focusing on properly diagnosing rare cases of LAST, adhering to safety precautions and correctly treating LAST.

Study limitations

As with online surveys, our response rate was poorer than expected. Therefore, the results represent the study group, but may not represent the overall population of surgical registrars using LA agents. The study was subject to responder bias with the risk of respondents doing an internet search while undertaking the survey. The study data is limited to a single centre.

Conclusion

Despite regularly using LA agents, the registrars lacked knowledge regarding clinical manifestations of LAST, the maximum recommended doses of LA agents, the minimum monitoring required during procedures and the specific treatment of LAST. LAST is a potentially fatal complication and the ability to recognise and manage this situation timeously could save lives. These factors can be improved by knowledge-based and simulation training as well as awareness campaigns.

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Conflict of interest
The authors declare no conflict of interest.

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Ethical approval
Ethical approval was obtained from Health Research Ethics Committee (HREC) of Stellenbosch University (S20/05/130).

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References

1. Calatayud J, González A. History of the development and evolution of local anesthesia since the coca leaf. Anesthesiology. 2003;98(6):1503-8. https://doi.org/10.1097/00000542-200306000-00031.
2. Lukawska J, Caballero MR, Tsabouri S, Dugué P. Hypersensitivity to local anaesthetics - 6 Facts and 7 myths. Curr Allergy Clin Immunol. 2009;22(3):117-20.
3. Van der Nest L. Local anaesthetic agent systemic toxicity. CME. 2012;30(6):215-6.

4. Rajan N. Management of severe local anesthetic toxicity. Update in Anaesthesia. 2009;25(2):74-79.
5. Miller RD, Cohen NH, Eriksson LI, et al. Miller's Anesthesia. 8th ed. Philadelphia, PA: Churchill Livingstone/Elsevier; 2015.
6. Christie LE, Picard J, Weinberg GL. Local anaesthetic systemic toxicity. BJA Education. 2015;15(3):136-42. https://doi.org/10.1093/bjaceaccp/mku027.
7. Macfarlane AJR, Gitman M, Bornstein KJ, El-Boghdadly K, Weinberg G. Updates in our understanding of local anaesthetic systemic toxicity: a narrative review. Anaesthesia. 2021;76(Suppl 1):27-39. https://doi.org/10.1111/anae.15282.
8. Gitman M, Fettiplace MR, Weinberg GL, Neal JM, Barrington MJ. Local anesthetic systemic toxicity: a narrative literature review and clinical update on prevention, diagnosis, and management. Plast Reconstr Surg. 2019;144(3):783-95. https://doi.org/10.1097/PRS.0000000000005989.
9. Di Gregorio G, Neal JM, Rosenquist RW, Weinberg GL. Clinical presentation of local anesthetic systemic toxicity: a review of published cases, 1979 to 2009. Reg Anesth Pain Med. 2010;35(2):181-7. https://doi.org/10.1097/AAP.0b013e3181d2310b.
10. El-Boghdadly K, Pawa A, Chin KJ. Local anesthetic systemic toxicity: current perspectives. Local Reg Anesth. 2018;11:35-44. https://doi.org/10.2147/LRA.S154512.
11. Karasu D, Yılmaz C, Özgünay ŞE, et al. Knowledge of the research assistants regarding local anaesthetics and toxicity. Turk J Anaesthesiol Reanim. 2016;44(4):201-5. https://doi.org/10.5152/TJAR.2016.53138.
12. Weinberg G. Current evidence supports use of lipid rescue therapy in local anaesthetic systemic toxicity. Acta Anaesthesiol Scand. 2017;61(4):365-8. https://doi.org/10.1111/aas.12870.
13. Litz RJ, Popp M, Stehr SN, Koch T. Successful resuscitation of a patient with ropivacaine-induced asystole after axillary plexus block using lipid infusion. Anaesthesia. 2006;61(8):800-1. https://doi.org/10.1111/j.1365-2044.2006.04740.x.
14. Rosenblatt MA, Abel M, Fischer GW, Itzkovich CJ, Eisenkraft JB. Successful use of a 20% lipid emulsion to resuscitate a patient after a presumed bupivacaine-related cardiac arrest. Anesthesiology. 2006;105(1):217-8. https://doi.org/10.1097/00000542-200607000-00033.
15. Collins J. Awareness of local anaesthetic toxicity issues among hospital staff. Anaesthesia. 2010;65(9):960-1. https://doi.org/10.1111/j.1365-2044.2010.06472.x.
16. Association of Anaesthetists of Great Britain and Ireland. Management of severe local anaesthetic toxicity guidelines. Anaesthesia. 2008;63(7):778-9. https://doi.org/10.1111/j.1365-2044.2008.05588_1.x.
17. Neal JM, Neal EJ, Weinberg GL. American Society of Regional Anesthesia and Pain Medicine local anesthetic systemic toxicity checklist: 2020 version. Reg Anesth Pain Med. 2021;46(1):81-82. https://doi.org/10.1136/rapm-2020-101986.
18. Urfalıoğlu A, Urfalıoğlu S, Öksüz G. The knowledge of eye physicians on local anesthetic toxicity and intravenous lipid treatment: questionnaire study. Turk J Ophthalmol. 2017;47(6):320-5. https://doi.org/10.4274/tjo.79446.
19. Walsh AM, Moran B, Walsh SA. Knowledge of local anesthetic use among dermatologists. Dermatol Surg. 2012;38(6):882-7. https://doi.org/10.1111/j.1524-4725.2012.02409.x.
20. Oksuz G, Urfalioglu A, Sekmen T, et al. Dentists knowledge of lipid treatment of local anaesthetic systemic toxicity. Niger J Clin Pract. 2018;21(3):327-31.
21. Edwards AE, Bowsher GM, Deepak S, Ali M. Improving local anaesthetic systemic toxicity (LAST) awareness in maternity care using tailored educational tools. BMJ Open Qual. 2018;7(2):e000070. https://doi.org/10.1136/bmjoq-2017-000070.
22. Sagir A, Goyal R. An assessment of the awareness of local anesthetic systemic toxicity among multi-specialty postgraduate residents. J Anesth. 2015;29(2):299-302. https://doi.org/10.1007/s00540-014-1904-9.
23. Khalid U, Zaidi A, Lamyman M, Swan M. Local anaesthetic toxicity: focused teaching improves surgeons' knowledge. Int J Surg. 2013;11(8):686. https://doi.org/10.1016/j.ijsu.2013.06.530.
24. Cooper BR, Moll T, Griffiths JR. Local anaesthetic toxicity: are we prepared for the consequences in the emergency department? Emerg Med J. 2010;27(8):599-602. https://doi.org/10.1136/emj.2009.079038.
25. Blucher N, Pefanis D, Janes C, Ahluwalia R. Do surgical trainees know how to administer local anaesthetic and deal with toxicity? Bullet R College Surg Eng. 2015;97(2):e4-8. https://doi.org/10.1308/147363515X14134529300229.
26. McKevith J, Rathi S, El Sayed H, Mills K. Lipid emulsion: is there sufficient knowledge among hospital staff? Anaesthesia. 2010;65(5):535-6. https://doi.org/10.1111/j.1365-2044.2010.06320.x.
27. Scarth E, Smith S. Drugs in anaesthesia and intensive care. 5th ed. New York: Oxford University Press; 2016. https://doi.org/10.1093/med/9780198768814.001.0001.
28. Safety Committee of Japanese Society of Anesthesiologists. Practical guide for the management of systemic toxicity caused by local anesthetics. J Anesth. 2019;33(1):1-8. https://doi.org/10.1007/s00540-018-2542-4.
29. Klein AA, Meek T, Allcock E, et al. Recommendations for standards of monitoring during anaesthesia and recovery 2021: guideline from the Association of Anaesthetists. Anaesthesia. 2021;76(9):1212-23. https://doi.org/10.1111/anae.15501.
30. South African Society of Regional Anaesthesia. SASA guidelines for regional anaesthesia in South Africa [Internet]; 2016. Available from: https://www.sasaweb.com/wp-content/uploads/2022/07/SASRA-guidelines-2016.pdf.

Appendix available online