Review Article
Local Anaesthetic Myotoxicity Due to Fascial Plane Blocks: A Brief Review

Abhijit S Nair*
Department of Anaesthesia and Pain Medicine, Basavatarakam Indo-American Cancer Hospital and Research Centre, Hyderabad-500034, India

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*Corresponding author: Dr. Abhijit S Nair, Consultant Anesthesiologist, Department of Anaesthesia and Pain Medicine, Basavatarakam Indo-American Cancer Hospital and Research Centre, Hyderabad-500034, India, E-mail: abhijitinair95@gmail.com

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Introduction
Local anaesthetic induced myotoxicity (LAMT) is terminology which is known and described as early as in 1959 in experimental animals and was documented in case reports [1]. Case reports and series are still published which describes the morbidity and undesirable consequences due to a confirmed LAMT. The present brief communication offers a revision on the mechanism of these injections. Another aim is to discuss the myotoxic potential of the currently used fascial plane blocks which are high volume injections and are performed via transmuscular approach using ultrasonography.

LAMT revisited
All local anaesthetics (LA) are myotoxic at the concentration used in clinical practice. After an LA injection into the muscle, the myofibrils become hypercontracted followed by degeneration of sarcoplasmic reticulum of the striated muscle with myocyte edema and necrosis. These are the findings on histopathological examination. The myoblasts, basal laminae and connective tissues are preserved after a single injection. Subsequently the muscle regenerates provided the ongoing insult with further exposure of LA is stopped [2]. This reversibility is affected after a continuous catheter based infusion or after a high volume, concentrated single shot LA injection.

The branches of nerves supplying the muscle and the blood supply to the muscle is not affected after these injections.

Once injected into the substance of the muscle, the LA leads to increased myoplasmic levels of free calcium which is responsible for muscle tissue necrosis [3]. Thus the LA injection causes toxicity in 3 ways: volu-trauma (by the volume of injected LA), baro-trauma (by the pressure of injection), chemical trauma (due to disruption in intracellular calcium homeostasis).

LAMT in the form of myonecrosis and muscle weakness are commonly seen after peripheral nerve blocks, wound infiltration, trigger point injections and ophthalmic injections like peribulbar and retrobulbar blocks. There is a dose dependent increase in LA induced muscle injury which was demonstrated by Cherng et al. [4]. The study was conducted on rats who were injected different concentrations of bupivacaine on the right tibialis anterior muscle and was compared with saline injections. Intramuscular glutamate which is a marker of muscle injury was more in LA group with more injury in the rats who were subjected to a more concentrated LA injection.

Many clinicians use adjuvants in the LA like epinephrine, alpha-2 agonists, dexamethasone, and opioids in the LA solution for prolonging the duration of analgesia after a block. The effect of these adjuvants on the myotoxicity conferred by LA is not known and not studied in detail till now.

Comparative toxicity
Among the LA commonly used clinically for regional anaesthesia, bupivacaine and chlorprocaine produces severe...
myotoxicity with procaine and tetracaine having the least toxicity profile [5]. Ropivacaine appears to be less myotoxic compared to bupivacaine but it is not clear whether the lesser myotoxicity is due to the pure physical isomer structure of ropivacaine. One possible explanation of this could be the more lipophilic nature of bupivacaine which leads to faster entry into the myoplasm leading to more calcium release [6]. In an experimental study by Yildiz et al on rats, the investigators found the myotoxicity of levobupivacaine after intramuscular injections of LA was qualitatively similar and quantitatively less than bupivacaine and ropivacaine [7].

USG guided peripheral nerve block, fascial plane block and myotoxicity:

With the increasing use of ultrasound in the practice of regional anaesthesia and pain medicine; the blocks have become safe, success rate has increased and the volume of drug required for an optimal block is reduced. This has reduced the chances of local anaesthesia systemic toxicity (LAST) as injections are given under direct vision and in real time with an overall lesser volume of LA. The plexus blocks (interscalene, supraclavicular, infraclavicular, axillary) and femoral nerve blocks are given by direct visualization of neural structures on USG [8]. The volume of LA required for these blocks with the use of USG has reduced significantly. Blocks like popliteal, sciatic, obturator, ilioinguinal–iliohypogastric are administered after identification of the nerves on USG but the target area of injection is reached by a transmuscular route.

Therefore chances of LAMT is again a possibility in these injections. The commonly used nerve blocks and fascial plane blocks with the muscles related to the block is shown in Table 1.

The chances of LAMT is theoretically more in the fascial plane blocks like transverses abdominal plane (TAP) block, sciatic, obturator, ilioinguinal–iliohypogastric and the target fascial plane. The nerves or the plexuses are not visualised in the above mentioned blocks unlike the brachial plexus and individual nerve blocks where the nerve/plexus is visualised and targeted in real time. Adductor canal block is a similar block where the nerve is not visualised out of the times and the injection is given in a fascial plane involving muscles of thigh by a trans-muscular approach [13].

The chances of myotoxicity increases if catheters are placed in the fascial plane as there is continuous infusion of LA, the drug might either get spilled in the substance of muscle if catheters get displaced or there can be direct intramuscular deposition of local anaesthetic. Neal et al., reported 3 cases who had LA induced myotoxicity following adductor canal block for total knee arthroplasty [14]. The patients developed progressive, profound quadriceps weakness from postoperative day 1 onwards. On clinical examination, MRI and after neurophysiologic studies, the impression was consistent with myositis. Complete recovery of these patients took several weeks to months.

The muscles of abdomen and chest are not directly associated weight bearing joints unlike the muscles of lower limbs. However in situations where the injection is through a weight bearing muscle like an adductor canal block (sartorius, adductor longus and vastus medialis muscle), popliteal nerve block (biceps femoris muscle), sciatic nerve block (through gluteus muscles); the resultant myotoxicity could be a cause of concern in rehabilitation of the patient in the postoperative period.

Conclusion

The incidence of LAMT is not known. A high volume block can increase the chances of myotoxicity. Similarly, continuous LA infusions can lead to a continuous muscle insult which can have undesirable consequences in certain situations. Fascial plane are high volume blocks hence could lead to myotoxicity which may get revealed only when weight bearing joint muscles are affected. The patients should be prospectively followed and evaluated to have a definitive number which can tell us which particular block can lead to myotoxicity. Further animal studies needs to be done to know maximum concentration or maximum volume of LA which can be safely injected in order to minimise myotoxicity after certain blocks.

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Table 1: Frequently performed ultrasound guided blocks and the muscles around the target neural structures or the target fascial plane.

| S.no. | BLOCK | MUSCLES |
|-------|-------|---------|
| 1     | Transversus abdominis plane block | External oblique, internal oblique, transversus abdominis |
| 2     | Serratus anterior plane block | Serratus anterior, teres major, latissimus dorsi |
| 3     | PECS 2 block | Pectoralis major and minor, serratus anterior |
| 4     | Adductor canal block | Sartorius, vastus medialis, adductor longus |
| 5     | Rectus sheath block | External oblique, internal oblique, transversus abdominis |
| 6     | Ilioinguinal–iliohypogastric nerve block | External oblique, internal oblique, transversus abdominis |
| 7     | Quadratus lumborum block | External oblique and internal oblique (aponeurosis), quadrates lumborum, psoas major |
| 8     | Popliteal nerve block | Biceps femoris, semitendinosus, semimembranosus |
| 9     | Sciatic nerve block | Anterior approach: Adductor muscles (longus, brevis, magnus), pectineus Gluteal approach: Gluteus maximus, quadratus femoris |
| 10    | Obturator block | Pectineus, adductor muscles (longus, brevis, magnus) |
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