Reinventing IM and Procedural Injections: The Sota Omoigui Short Needle Technique

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The authors describe a new, less painful technique using a smaller needle.

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Intramuscular and procedural injections are common practice in modern medicine and are used by virtually all clinical specialists. Millions of injections are administered worldwide every year for curative and preventive purposes.

In intramuscular (IM) injections, one of the most common routes of administration, medication is injected directly into a muscle, where it may be absorbed into the bloodstream quickly or gradually, depending on the viscosity and formulation of the medication, local blood supply, and depth of the injection. Principal injection sites are the deltoid muscle of the arm, the vastus lateralis muscle of the leg, and the ventrogluteal and dorsogluteal muscles of the buttocks. Needles used for IM injections generally are 1 to 1.5 inches long and 19- to 22-gauge in size.

Procedural injections (eg, nerve blocks, pain site injections, trigger point injections into the cervical, thoracic, or lumbar paraspinal muscles, epidural and facet injections) incorporate insertion of a needle through the skin, subcutaneous tissue, and muscle into deeper structures. Needles used for these injections generally are 1 to 3 inches long and 19- to 25-gauge in size.

A complication that may be associated with these injections is nerve trauma arising from needle contact with a nerve. Such complications can be minimized by the use of shorter, higher-gauge (smaller-bore) needles.

Table 1. Intramuscular Injections Guidelines: Skin Measurements, Needle Length and Gauge						
Location of Injection	Skin Thickness, mm	Subcutaneous Thickness, mm	Total Depth, mm	Needle Length, inch	Needle Gauge, G	Needle Angle
Arm (Deltoid muscle)	2.2	10.8	13.0	1”-1.5” (up to 3” for large adults)	19-22	90°
Thigh (Vastus lateralis muscle)	1.9	10.4	12.3	1”-1.5” (up to 3” for large adults)	19-22	90°
Abdomen	2.2	13.9	16.1	n/a	n/a	n/a
Hips (Ventrogluteal site)	n/a	n/a	n/a	1”-1.5” (up to 3” for large adults)	19-22	90°
Buttocks (Dorsogluteal site)[a]	2.4	15.4	17.8	1”-1.5” (up to 3” for large adults)	19-22	90°

n/a, not available

[a] Avoid dorsogluteal location in obese patients.

Factors Influencing the Injection Process

There are multiple factors that influence the selection of injection type as well as the injection process, including patient characteristics (size and weight), the site of the injection, and needle characteristics (length and gauge).

The skin has multiple layers of ectodermal tissue and guards the underlying muscles, bones, ligaments, and internal organs. For the average adult, the skin has a surface area of between 1.5 and 2 square meters (16.1- 21.5 square feet), with most being between 2 to 3 mm (0.10 inch) thick.[1] The various sites used for injections also have differing amounts of muscle and can affect the injection. Gibney et al used ultrasound to measure skin and subcutaneous adipose layer thickness at sites used for insulin injections in adult subjects (18-85 years) with diabetes and Basic Metabolic Indices between 19.4-64.5 kg/m^2 (Table 1).[1]

The appropriate choice of injection site helps prevent complications—for example, dorsogluteal injection should be avoided in obese patients and to prevent any nerve injury. Review of the literature found that injury to the sciatic nerve is associated with use of the dorsogluteal site for injection.[2] Therefore, when giving gluteal injections, it is safest to use the upper outer quadrant (ventrogluteal site).

Another safe alternative site is injecting into the lateral thigh (vastus lateralis), which avoids accidental sciatic nerve injection. The uptake of drugs from the thigh region is slower than from the arm (deltoid muscle) but faster than from the buttock, thus facilitating better drug serum concentrations than is possible with the gluteal muscles.[3] In fact, the vastus lateralis site can hold up to 2 mL of fluid. It can be used in patients administering their own medication and also in children.

The thickest part of the deltoid muscle is 2.5 to 5 cm below the lower edge of the acromion process of the scapular. The deltoid site is used especially in outpatient setting. However, caution is needed because of the close proximity of the radial nerve, brachial artery, and bony processes.

The ventrogluteal site provides the greatest thickness of gluteal muscle (consisting of both the gluteus medius and gluteus minimus), and is free of penetrating nerves and blood vessels, and has a narrower layer of fat of consistent thinness than is present in the dorsogluteal site.[4] This site may be the best choice for very thin patients.

The route of injection is dependent on the site to be injected and the nature of the medication to be injected.[5] For example, injecting vaccines into the layer of subcutaneous fat may result in slow mobilization and processing of antigen because there is poor vascularity compared to the muscular layer. When compared with IM administration,[6] subcutaneous injection of hepatitis B vaccine leads to significantly lower seroconversion rates and more rapid decay of antibody response.[7]

Administration of IM Injections

For IM injections, the current approach requires that a needle used to administer medication intramuscularly should be long enough to reach deep into the target muscle without penetrating the structures underneath. A slender individual with very little fatty tissue may need a 1-inch long needle, whereas someone heavier will need a 1½- to 3-inch needle.[8]

When administering an IM injection to the buttocks, the total depth from the skin to the muscle layer would be an average of 17.8 mm. Therefore, a 30 G, 1-inch (25-mm) needle will pass through the skin and subcutaneous tissue and penetrate only 7.2 mm into the

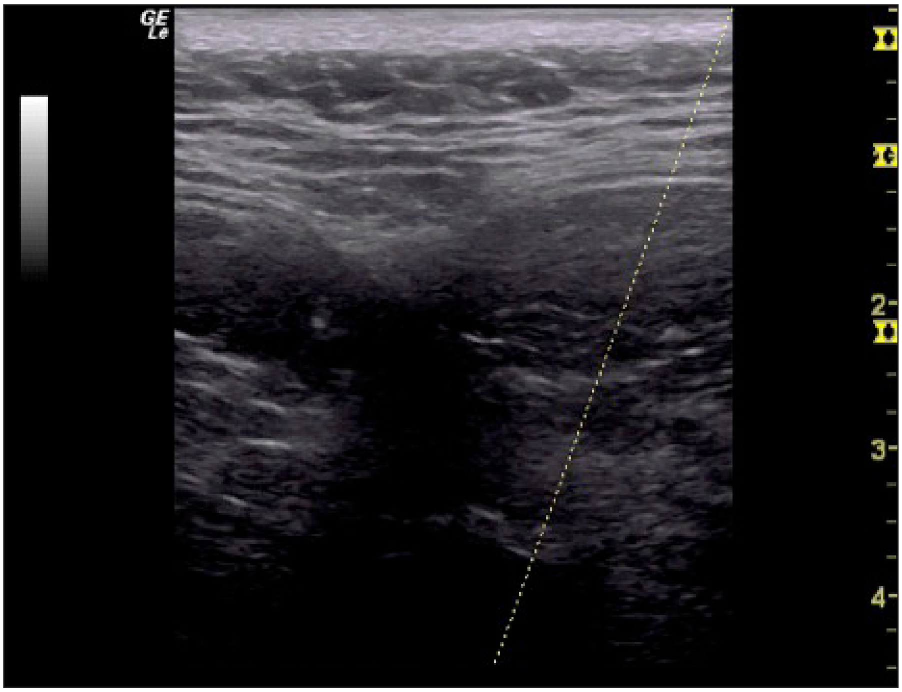


Figure 1. Ultrasound screen showing the depth reached by medication in tissue using a 30 G needle during a trigger point injection of the lumbar paraspinal muscle.

muscle whereas a 25 G, 1½-inch (37.5-mm) needle will penetrate 19.7 mm.

Complications of IM injections include bleeding, soreness, redness at the site, allergic reaction to the medication, infection, abscess, hematoma, pain at the injection site, nerve injury, numbness, and tingling.[9] However, serious reactions to IM injections are rare.

In one series of 26,294 adults, of whom 46% had received at least one IM injection, only 48 (0.4%) had a local adverse reaction.[7] Muscle is probably spared the harmful effects of substances injected into it because of its abundant blood supply.[2]

In contrast, subcutaneous injections can cause abscesses and granulomas.[3,5] Adipose tissue, having much poorer drainage channels, retains injected material for much longer and is, therefore, also more susceptible to its adverse effects.

Our Experience

At the L.A. Pain Clinic, we routinely perform IM and ultrasound-guided procedural injections to alleviate inflammation and relieve pain. During ultrasound guidance for spinal procedures, we have observed that a clear solution of lidocaine 2% injected from a 30-G, 5/8-inch (15.6-mm) needle using a 3-mL syringe and inserted just lateral to the spinous process into the paraspinal muscles travels a distance of 4 to 6 cm (Figure 1).

Insertion of the needle this distance was sufficient to allow the medication to travel down to the vertebral lamina and produce anesthetic block to relieve radicular pain from the nerve roots within minutes.

Subsequent to this observation, we modified our techniques for IM and procedural injections and replaced the longer, larger needles with shorter, higher-gauge needles. When a higher 30-gauge needle is used with a 3 mL-syringe (Figure 2), there is increased velocity through the smaller needle and the distance the medication travels from the syringe and needle into the tissue is greater. The principle of conservation of mass is embodied in the equation of continuity which states that, in any steady state process, the rate at which mass enters a system is equal to the rate at which mass leaves the system (Figure 3, page 32).

From our calculations, we concluded that the smaller inner diameter of the needle results in more than double the velocity through the needle and, thus, greater penetration into the tissues than the larger-bore needle. Therefore, the smaller the needle bore, the higher the pressure and the greater the distance traveled by medication into tissue.

There are a number of advantages to using a smaller-bore needle, including:

- Medication can be pushed under pressure using a smaller, shorter needle.
- Use of a small-bore needle significantly decreases the risk of needle trauma because the medication is injected under pressure to travel deep into the tissue rather than the needle traveling deeper into the tissue.
- Compression of the skin and subcutaneous fatty tissue reduces the distance required for penetration into the muscle. This needle also can be used in procedural injections as described below.

The initial administration of lidocaine 1% before the administration of the desired medication helps to numb the area, reducing the pain experienced when the medication is administered. The 30-G needle is in-situ while a new 3-mL syringe containing the medication is attached to the needle, thus preventing re-injection. Many patients prefer this new method because it is less traumatic.

There are limitations to this technique, however. This equation and its application apply only to injections of clear solution under pressure. For a viscous solution (eg, testosterone), wider-bore and longer needles will still need to be used. For IM injections with a 30-G, 5/8-inch needle, preferred injection sites are the deltoid (mean skin to muscle depth, 13 mm) and lateral thigh (mean skin to muscle depth, 12.3 mm). The gluteal muscles of the buttocks are not a preferred site in individuals with higher body fat and a skin to muscle depth greater than 17.8 mm. The distance to muscle may not be decreased adequately by compression to allow use of a 30-G, 5/8-inch needle in such patients.

Procedural Injections

For procedural injections, especially those involving the chest or abdominal walls, the depth of needle insertion is controlled by the angle of insertion of the needle. Once the needle is inserted past the subcutaneous tissue into the first muscle layer, the medication can be injected under pressure to reach the target site.

The average distance from the skin to the subacromial bursa via the anterolateral approach has been measured arthroscopically with needle placement at 2.9 cm +/- 0.6 cm.[10] Other research using radiographic contrast and fluoroscopy shows the average distance measured from the skin to the closest bursal border using an anterolateral approach is 2.1 cm.[11] The mean distance to the subacromial space via the posterior approach measured arthroscopically is 5.2 cm +/- 1.1 cm, nearly twice the depth required by the anterolateral approach.[10]

The distance from the skin to the ligamentum flavum in the lumbar spine is 3 to 8 cm.[12] The average distance from skin to the lamina with a paramedian approach (1 cm from the midline) is 4.2 cm in the upper thoracic spine, 3.7 cm in the middle thoracic spine, 3.6 cm in the lower thoracic spine and 4.0 cm in the lumbar spine. The average distance from skin to the epidural space with a paramedian approach is 5.6 cm in the upper thoracic spine, 5.2 cm in the middle thoracic spine, 4.4 cm in the lower thoracic spine, and 4.7 cm in the lumbar spine.[13]

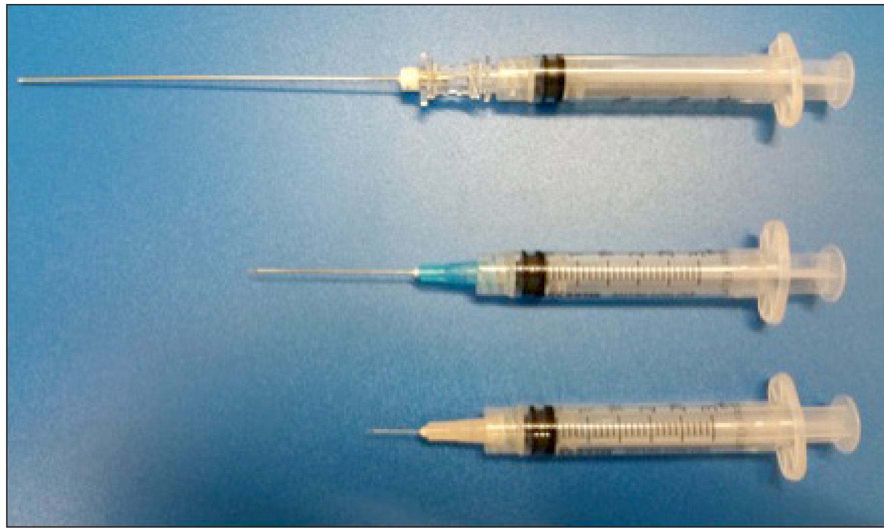


Figure 2. Comparing a 30-G, 5/8 inch needle with a 3 mL syringe (bottom) with a 25-G, 1 1/2 inch needle with a 3 mL syringe (middle), and a 22-G, 3 1/2 inch spinal needle with a 3 mL syringe (top).

It can, therefore, be seen that using a short, small-bore needle, such as the 30-G, 5/8-inch needle, medication can be delivered at a distance, under pressure, to travel to the vicinity of the target site. With ultrasound guidance for procedural injections of the cervical, thoracic, and lumbar paraspinal injections, the medication can be seen to flow to a distance of 4 to 6 cm into the paraspinal muscle, giving the desired relief within minutes.

Examples of traditional procedural injections and short-needle alternatives are given below.

Traditional Technique: Intercostal Nerve Block

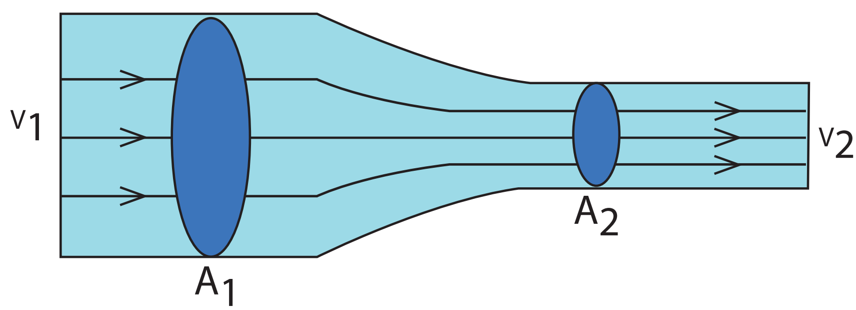
Intercostal nerve blocks are performed to alleviate pain from sources in the chest or abdominal wall (eg, a fractured or sprained rib). The classic technique for a posterior intercostal nerve block by Bonica[14] entails placing the patient in the lateral position with the target side up if performing a unilateral block or in prone position if performing bilateral blocks. A 3-cm (1.2-inch), 25-G short-beveled needle is inserted through a skin wheal at the lower edge of the posterior angle of the rib. The second finger of the left hand is placed over the intercostal space and the skin is pushed gently cephalad so that the lower edge of the rib above can be palpated simultaneously. This technique protects the intercostal space, thus reducing the risk of passing the needle into the lung.

The needle is advanced until the lower part of the lateral aspect of the rib is reached. After the rib is reached, the needle is grasped with the thumb and index finger of the left hand about 3-5 mm above the skin surface. The skin is moved caudally with the index finger to allow the needle to slip just below the lower border of the rib and then the needle is advanced until the left thumb and finger grasping the needle become flush with the skin. Aspiration is attempted; if it is negative, 3 to 4 mL of local anesthetic solution is injected.

The purpose of this technique is to inject local anesthetic solution as close as possible to the intercostal nerve as it travels in the subcostal groove.

Alternative Technique: Intercostal Nerve Block

It is not necessary and incurs more risk to advance a long needle to the target



Flow rate through A_1 = Flow rate through A_2

$d_1A_1v_1 = d_2A_2v_2$

Therefore, dAv = Constant

Where

A_1, area in tube 1; v_1, velocity in tube 1; A_2, area in tube 2; v_2, velocity in tube 2

Figure 3. Equation of Continuity. For our purpose, A1v1 represents the syringe and A2v2 represents the hypodermic needle.

nerve/site to be blocked. The medication can be delivered and distributed over the target site by injecting it under pressure from a short, small-diameter needle. This is herein described as the Omoigui Short-Needle Technique and applies to all procedural injections of clear solution.

With the Omoigui Short-Needle Technique for Intercostal Nerve Block, the left middle and index fingers are placed to stabilize the superior and inferior borders of the rib, respectively, at a site proximal to the area of pain. A short (30-G, 5/8-inch) needle is advanced just past the subcutaneous tissue into the muscle layer, and 1 to 2 mL of local anesthetic solution is injected over the rib. There is no attempt to walk off the lower border of the rib and there is no advancement of the needle into the subcostal groove. There is minimal to no risk of any accidental pleural puncture.

Current Technique: Epidural/Facet Block

Epidural/facet blocks are performed to alleviate pain from sources in the spine and surrounding tissues (eg, herniated disk, muscle spasm). The standard technique described for a fluoroscopic-guided facet nerve block is the placement of a 3½- to 5-inch spinal needle on the superior and medial point at which the transverse process joins the vertebra. The medial branch is targeted at the point at which the nerve curves around the top of the transverse process. Waldman described a technique in which 1.5 mL of local anesthetic with or without steroid is injected through the spinal needle after correct needle placement is confirmed by fluoroscopy.[15]

Using the standard technique for an epidural dorsal interlaminar approach, the patient is placed in the prone position. Under fluoroscopic guidance, a 22-gauge spinal needle is advanced to the posterior margin of the spinal canal. Positioning in the epidural space is detected with a loss-of-resistance technique. Gentle intermittent pressure is applied on a syringe while the needle is advanced. A sudden loss of resistance occurs when the needle enters the epidural space. An absence of cerebrospinal fluid flow is verified with aspiration.

Epidurography is performed with 2 to 3 mL of nonionic myelography approved iodinated contrast material to document epidural position and evaluate the distribution pattern. Local anesthetic with steroid is then injected into the epidural space.

Alternative Technique: Epidural/Facet Block

Again, it is not necessary and incurs more risk to advance a long needle to the target nerve/site to be blocked. The medication can be delivered and distributed over the target site by injecting it under pressure using the Omoigui Short Needle Technique.

Studies have shown that a transforaminal epidural injection provides no benefit over the short-needle interlaminar technique and is associated with additional risk of significant neurologic disaster. In one study evaluating patients 2 weeks post injection, the results in terms of efficacy were virtually identical and indistinguishable. On the contrary, there was a very slight, and probably not clinically significant, enhancement in functionality with interlaminar epidural steroid injection.[16]

In another study, intravenous dexamethasone was found to be equivalent to perineural dexamethasone for prolonging the analgesic duration of a single-shot interscalene brachial plexus block with ropivacaine.[17]

With the Omoigui Short Needle Technique for Spinal Pain, the spine is palpated to locate the most painful sites. A short (30-G, 5/8-inch) needle is inserted immediately adjacent to the spinal process at those sites. The needle is advanced just past the subcutaneous tissue into the muscle layer, and 1 to 2 mL of local anesthetic solution (preferably 2% lidocaine) is injected. If the injection is performed under ultrasound guidance, the solution will be seen to spread 4- to 6-cm deep into the paraspinal muscle to the lamina. The injection is repeated at the 2 to 5 most painful sites.

The needle can be inserted straight down or at an angle anywhere in the cervical, thoracic, or lumbar spine. By understanding the depth of any vital structures you wish to avoid and inserting this needle at an angle as needed, it will be nearly impossible to penetrate and traumatize any vital structures. The number of sites injected is constrained by the amount of local anesthetic injected to avoid a toxic dose of anesthetic.

Local anesthetic injections have a therapeutic effect that exceeds blocking the nerves. They reduce nerve inflammation by preventing nerve traffic that is a significant contributor of inflammation and pain. Afferent nerve barrage results in release of inflammatory cytokines and neuropeptides, such as Substance P, calcitonin gene-related peptide (CGRP), and bradykinin.[18,19]

Procedural injections using the Omoigui Short Needle Technique must be combined with an anti-inflammatory regimen, which may include an IM/IV nonsteroidal anti-inflammatory drug, such as ketorolac, or an IM/IV corticosteroid, such as methylprednisolone or dexamethasone, combined with IV infusions of neuromodulators (eg,magnesium sulfate and valproic acid).

Anesthetic injections often have been combined with epidural steroids injections, with the assumption that the therapeutic effect is mainly from the steroids, which have to be injected locally. However, epidural steroids do not need to be injected into the pain site in most patients. Recent studies have shown that the therapeutic effect is mostly from the anesthetic. In one study of patients with lumber spinal stenosis, there was no difference in pain relief between epidural injections with lidocaine alone and epidural injections with lidocaine and steroid.[20]

Summary

Administering an IM or a procedural injection is safer with the use of a smaller-gauge needle that is long enough to get past subcutaneous tissue into the first muscle layer and deliver injected medication under pressure close to the target, but avoids penetrating underlying structures. The era of using larger-gauge needles should be reassessed, except for oil-based fluids. The use of smaller-gauge needles reduces complications of IM or procedural injections. However, quality of the needle and the bevel design is important in producing an atraumatic injection.[21] Patients who come in with pain, including radicular pain, experience significant decrease in their pain scores or complete relief, after procedural injections using the Omoigui Short Needle Technique.

If the injection is performed under ultrasound guidance, the solution will be seen to spread 4- to 6-cm deep into the paraspinal muscle to the lamina.

Authors' Bios: *Sota Omoigui, MD, is Medical Director of the L.A. Pain Clinic and former member of the FDA Advisory Committee on Anesthetics and Life Support Devices (2008–2011). Dr. Omoigui is author of* Sota Omoigui's Law of Pain, *which states that the origin of all pain is inflammation and the inflammatory response. His theory of pain and numerous articles in medical journals are cited in hundreds of journal articles.*

Other publications by Dr Omoigui include Sota Omoigui's Anesthesia Drugs Handbook – *4th Edition (State-of-the-Art Technologies, 2010),* The Biochemical Origin of Pain *(State-of-the-Art Technologies, 2002), Sota Omoigui's* Pain Drugs Handbook *(Blackwell Scientific Publishers, 1999),* The Anesthesia Drugs Handbook *(Mosby Yearbook Publishers, 1995),* The Pain Drugs Handbook *(Mosby Yearbook Publishers, 1996),* Pain Relief—The L.A. Pain Clinic Guide *(State-of-the-Art Technologies, 1998), and* The Universal Drug Infusion Ruler *(State-of-the-Art Technologies, 1995). Dr. Omoigui's drug handbooks are used worldwide and have been published in 6 other languages (including Indonesian, Italian, Japanese, Malaysian, Polish and Portuguese).*

Dr. Omoigui's research focus is on

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