REVIEWS AND DISCUSSION PAPERS

Choosing wisely: needle length and gauge considerations for intramuscular and subcutaneous injections

AUTHORS

REGINA LAU RN, PGDipPaed, PGDipMid, MClinNg[1]

CORRESPONDING AUTHOR

REGINA LAU Nurse Practitioner Clinics Australia (Karawara Clinic), East Metropolitan Health Service.
E: vege67@bigpond.com

ABSTRACT

Objective: This article aims to address knowledge gaps and misconceptions among healthcare professionals regarding needle selection (specifically the length and gauge/size chosen) for intramuscular (IM) and subcutaneous (SC) injections. It investigates the impact of needle selection on injection efficacy and adverse effects, considering factors, such as, needle length, size, patient characteristics, and medication requirements. It also aims to evaluate current injection guidelines against research findings from the past two decades, identifying areas requiring revision or updating.

Methods: The discussion paper employs a literature review, including an analysis of past research that employs imaging techniques, such as, CT and ultrasound to examine tissue depth in both IM and SC injection practices; the author's extensive experience across various clinical settings, including immunisation, primary care, and acute care settings. The author's roles as academic staff and a clinical facilitator allow for the identification of gaps between theoretical knowledge and practical implementation in injection practices. These insights contribute to a comprehensive understanding of the challenges faced by healthcare professionals.

Results: The study reveals significant discrepancies in needle selection practices, with traditional methods often diverging from evidence-based recommendations. Challenges noted include reliance on needle hub colour coding for IM and SC injections and insufficient understanding regarding the rationale behind these injection methods. Another additional barrier is interpreting needle packaging information to identify the actual needle length for injection. Staff training and education is essential to improving accuracy and safety in injection practices. Further, patient characteristics, such as, weight, BMI, gender, and injection sites were found to impact needle selection, highlighting the need for tailored approaches. The article suggests that inconsistent and outdated guidelines from various agencies in injection practices and techniques often lack robust scientific rationale.

Implications for research, policy, and practice: The findings and recommendations have significant implications for healthcare policies and guidelines. They highlight the need to incorporate research findings to update current guidelines, ensuring safe and effective injection practices across all clinical settings. An algorithmic flow chart could be developed to reflect the above concerns.

What is already known about the topic?

- Nursing textbooks often differ in IM and SC procedures, with some based on non-evidence-based recommendations.
- Unsafe injections have severe consequences, including increased morbidity and mortality, along with substantial medical costs.
- Complications like muscle fibrosis, abscesses, gangrene, and nerve injury may arise. Inappropriate injections can result in subtherapeutic absorption and reduced medication efficacy.

What this paper adds:

- This article highlights the overreliance on traditional practices in injection procedures and advocates for nurses to embrace evidence-based approaches in their injection techniques.
- It also emphasises the importance of proper needle selection, including the correct identification of length and gauge/size (rather than relying solely on the needle colour hub for IM/SC injections), to ensure medication efficacy and patient safety.
- This shift towards best practice is anticipated to enhance nursing proficiency in intramuscular and subcutaneous injections, ultimately leading to improved patient outcomes.

Keywords: Drug efficacy and adverse reactions; Evidence-based practice; Injection practices; Intramuscular (IM) injections; Needle length and size; Parenteral administration; Patient safety; Knowledge deficits; Subcutaneous (SC) injections

INTRODUCTION

Administering injections is a critical responsibility in nursing that demands extensive knowledge and expertise. Nurses must have a thorough understanding of injection techniques, appropriate needle size and length, medication requirements, and potential complications of injections. Unfortunately, traditional injection practices are still being used even though research spanning several decades has revealed evidence that contradicts these practices.[1-3] Many nursing fundamentals textbooks recommend different injection procedures based on traditional and non-evidence-based practices.[4]

Although guidelines dictating needle length for intramuscular (IM) and subcutaneous (SC) injections exist, they vary and do not always reflect evidence-informed practice, leading to confusion among healthcare professionals. In Australia's healthcare landscape, there are discrepancies in injection practices within hospitals and primary healthcare facilities, which have the potential to jeopardise patient safety. Standard 4 of the National Safety and Quality Health Service (NSQHS) on Medication Safety and the Primary Health Care Standards emphasises the safe and appropriate use of medicines, including injections, in order to minimise harm to patients.[5] Healthcare providers must have the knowledge, skills, and training to administer medications safely. The Primary Health Care Standards require healthcare providers to implement evidence-based practices and clinical guidelines to ensure appropriate patient care. However, the lack of updated guidelines that reflect current research findings, coupled with inadequate training and knowledge among staff members, can compromise patient safety.

The article investigates common injection practices among nursing professionals in Australia, shedding light on knowledge gaps and misconceptions surrounding needle selection for both IM and SC injections. It also addresses challenges stemming from differences in manufacturers' products and measurement units across countries.

The importance of needle gauge selection is also explored, considering various factors influencing the choice of needle.

The final section focuses on needle length, examining IM and SC injection practices individually. It investigates how various factors influence injection efficacy, such as, patient gender, size/BMI, site of injection, and medication property. It also utilises previous research findings to improve comprehension and identify areas for improvement.

THE IMPORTANCE OF ACCURATE NEEDLE GAUGE AND LENGTH

Selecting an appropriate needle size and length is critical for ensuring the safe and effective delivery of medications to an intended site. Unsafe injection practices have been shown to have significant negative impacts on patient health, including increased rates of morbidity and mortality, as well as millions of dollars spent on direct medical care.[6] The Government of Western Australia *Vaccine Safety Surveillance Annual Report 2021* for childhood vaccination revealed injection site reactions to be the most common adverse event following immunisation.[7] Aside from common adverse effects, such as, pain, bruising, and hematoma formation,[7] other complications may be associated with IM or SC injections. These include sciatic nerve injury, particularly with IM injection in the upper outer quadrant of the buttock; osteomyelitis if the IM injection is too deep and the formation of granulomas, fat necrosis, and calcification

following SC injections.[8-10] When administering insulin, the appropriate needle length is critical for achieving optimal glycaemic control and avoiding complications, such as, fluctuations in blood glucose levels, needle phobia, and poor treatment compliance.[11]

KNOWLEDGE OF INJECTION TECHNIQUES AND NEEDLE IDENTIFICATION

Studies have shown that healthcare professionals may receive insufficient training in injection techniques, and therefore, may need ongoing education and training to narrow the knowledge gap about techniques.[12] Various approaches have been described, such as the z-track method, 45/90-degree needle insertion, and skin flattening or bunching (squeezing).[1, 13, 14] However, the techniques often overlook the importance of selecting the right needle gauge and length for the injection. Both the technique and needle specifications are vital for success. In a study by Davidson and Bertram, the bunching technique was successful in nearly 80% of deltoid IM injections, using a 25 mm needle in older adults, while flattening led to over-penetration more than 85% of the time.[15] A 32 mm needle over-penetrated the deltoid muscle, posing a high risk of hitting the bone, whether a bunching or flattening technique was used.[15] Nurses have stated that they use either technique out of habit, but they must understand the rationale for their actions and consider the appropriate needle stock and technique to ensure accuracy and safety.

It is a common misconception among both novice and experienced nurses in Australian healthcare settings that the colour of the needle hub indicates how the needle should be used. For instance, there is a common belief that orange-hubbed needles are solely for subcutaneous (SC) injections, while blue-hubbed needles are IM injections, aligning with the familiar nursing adage "blue for IM and orange for SC".[16] However, this assumption is not always accurate and may lead to erroneous administration, such as, giving an intramuscular (IM) injection into subcutaneous (SC) tissue or vice versa.

A universal standard established by the International Organisation for Standardisation (ISO) has been implemented to standardise the colour coding of hypodermic needle hubs globally.[17] Needles with hubs of the same colour, such as, green, come in several lengths. For example, orange-hub needles can be 16, 25, or 38 mm in length, and blue-hub needles can be 16, 19, 25, or 32 mm in length. Therefore, relying on the hub colour to determine the needle's intended use can lead to confusion and errors (Figure 1).

Another issue is that nurses may choose a needle because it is available in the needle stock in their ward or clinic, even though it is inappropriate for the type of injection given.

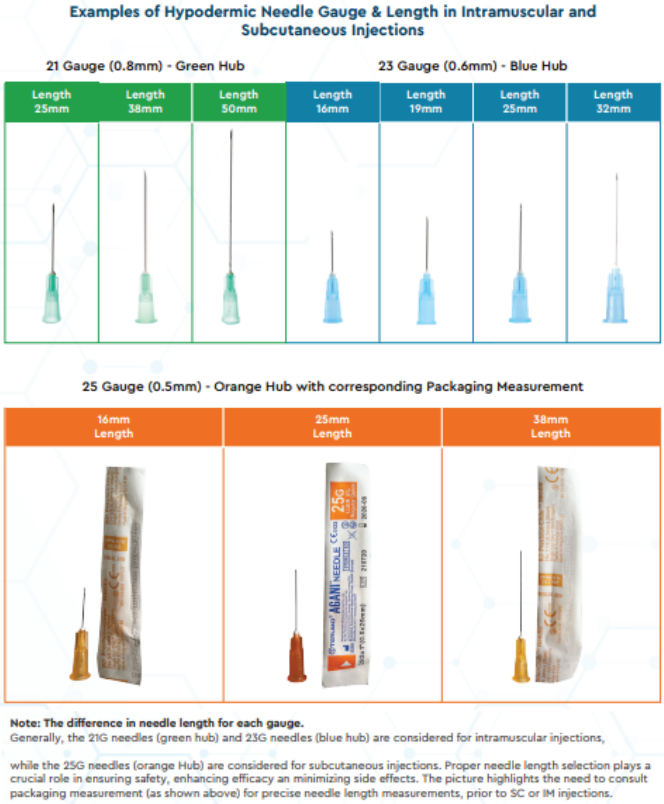

FIGURE 1. COMMON NEEDLE SIZES/LENGTH FOR IM AND SC INJECTIONS

Healthcare professionals may not be aware of the numbers and types of needles manufactured by various companies or informed of changes in companies' current practices. The length of the needle is indicated on the packaging, along with other relevant information, such as, the gauge. Frequently, the print on needle packages is small and hard to see, as for the 25G orange-hub needle in Figure 1. Many manufacturing companies display pictures of needles with hubs of various colours on their websites. However, there is often no visual indication of the different needle lengths associated with each hub and its gauge. This lack of clarity can be confusing and lead to misunderstandings among the public and healthcare professionals alike.

The units of measurement for needle length vary in different countries, and this may confuse healthcare professionals who are training or practising in a country different from the one in which needles are manufactured. For example, needle length is measured in inches in the United States, but in millimetres in other countries, such as, Australia and the United Kingdom. Unfamiliarity with different units of measure can result in errors when selecting needle lengths. In this paper, we focus on needle lengths in millimetres.

NEEDLE GAUGE: A BALANCING ACT BETWEEN INJECTION PRESSURE, PAIN, AND BLEEDING RISK

The needle gauge (G) system is an internationally recognised scale used for needle sizing, established by the International Organization for Standardization (ISO).[17] The size of a needle, or the diameter of the needle's lumen, is crucial.[18] Gauges range from 7 (the largest) to 33 (the smallest); the higher the gauge number the smaller the needle diameter (Table 1).

TABLE 1. NEEDLE GAUGE AND DIAMETER

Needle Gauge (G)	Diameter (mm)
18	1.2
19	1.0
21	0.8
22	0.7
23	0.6
25	0.5

Hypodermic needles follow the ISO colour coding system for identification, with the examples shown below ranging from larger to smaller (Figure 2).

Selecting an appropriate needle gauge is crucial for ensuring effective medication delivery, while minimising pain and local reactions. Considerations should include injection pressure, pain reduction, bleeding risk, local reactions, and the viscosity of the solution being administered.[19] Nurses must critically assess various factors when choosing the right needle gauge for administration.

Hunter recommended the use of a 21G needle for IM injections in adults to ensure accurate administration into the muscle.[16] The validity of this claim is brought into question when the recommendation is made without considering the needle length, medication type, or patient-specific factors. Additionally, needle gauges have been shown to significantly affect the frequency of pain during needle insertion. Using a smaller gauge needle, such as, a 31G, can reduce the likelihood of pain compared with larger gauge needles, such as, 27G or 28G.[16] Decreasing the needle diameter has been observed to decrease the likelihood of bleeding during insertion.[18]

NEEDLE GAUGES FOR VARIOUS FORMULATIONS AND LEVELS OF VISCOSITY

When selecting the needle gauge, it is important to consider the viscosity (thickness) and volume of the solution being administered. High-viscosity solutions, such as, certain forms of testosterone, Fulvestrant (oncology therapy), and oil-based antipsychotics, necessitate a wider bore needle to facilitate easier administration and reduce the risk of localised tenderness and erythema.[20] These formulations often come in larger volume (>3mL). By opting for a wider bore needle in IM injections, the pressure required to administer solutions can be reduced. Conversely, smaller gauge needles may require more force to be used in administering injection against resistance or pressure. The primary objective of this approach is to disperse the medication over a broader area, effectively minimising the likelihood of local reactions. A 21G with a longer-length needle is recommended for injection in appropriate sites.[20]

According to Diggle, in infants and children, using a wider gauge needle, such as, a 23G, may slightly decrease the incidence of local reactions compared with a 25G 16-mm needle while still achieving a comparable immune response.[21]

CLINICAL IMPLICATIONS OF NEEDLE SELECTION

It is important to select an appropriate needle gauge based on patient characteristics and the specific medication being administered, aiming to balance pain reduction, injection depth, and the risk of local reactions. Consider the viscosity (thickness) and volume of the solution when selecting the needle gauge, especially for high-viscosity formulations, such as testosterone or hormonal drugs. A wider-needle gauge needle, such as a 21G (green-hub) needle, may facilitate a smoother flow of solution from the syringe through the needle than a 25G (orange-hub) needle. Regarding infants and children, a 23G or 25G needle for IM injections should be considered to disperse the medication and reduce the risk of local reaction.

NEEDLE LENGTH FOR INTRAMUSCULAR INJECTIONS

Injections into muscle (IM injections) are used for medications that require rapid absorption into the bloodstream, such as, certain vaccines, antibiotics, hormones, and pain relief medications. Muscle tissue is more vascular than SC tissue. Administering an SC injection instead of an IM injection into muscle tissue can lead to improper drug absorption, which can affect a medication's effectiveness.[6] Additionally, adipose tissue retains injected material for longer periods than muscle, so injections into adipose tissue have an increased potential for adverse effects. IM injections are defined as injections in which the needle tip pierces the muscle by at least 5 mm (Figure 3).[20]

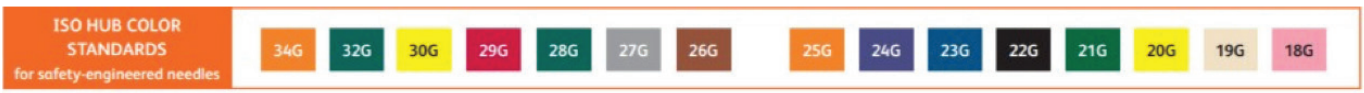

FIGURE 2. ISO HUB COLOUR STANDARD FOR SAFETY-ENGINEERED NEEDLES [17]

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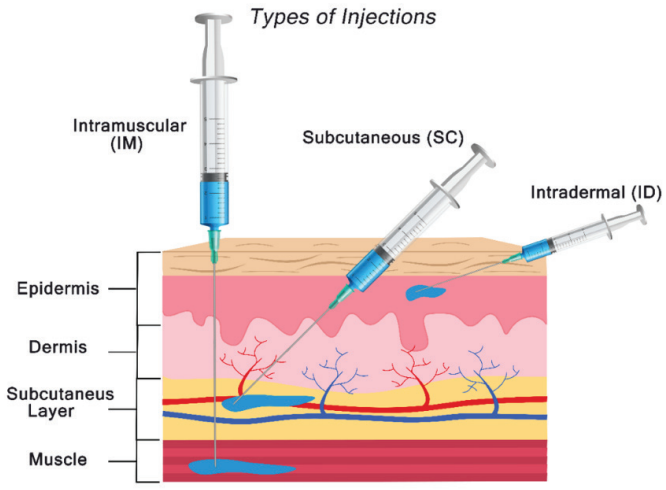

FIGURE 3. NEEDLE PENETRATION DEPTH FOR IM AND SC INJECTIONS

The most common sites for IM injection include:

- The deltoid muscle of the arm,
- The vastus lateralis muscle of the thigh,
- The ventrogluteal muscle of the hip, and
- The dorsogluteal muscles of the buttocks (historically used, but less recommended at present due to safety concerns).

FACTORS AFFECTING THE EFFICACY OF IM INJECTIONS

The choice of needle is usually at the discretion of the person administering the injection, although there may be guidelines on choice that can be consulted. Certain IM injections, such as, those for depot antipsychotics, come with pre-packaged needles and specific instructions. Needles used for IM injections are typically 25 to 38 mm (1 to 1.5 inches) long and 19G to 25G. For instance, a 25G needle 25 mm long is recommended for influenza and COVID-19 vaccinations in Australia.[14]

In selecting the right needle, it is essential to consider the patient's characteristics, such as, weight, BMI, gender, age, injection site, muscle size, and the volume of material to be administered, and to base the decision on the individual patient to ensure the needle reaches the appropriate tissue layer.[14, 22, 23] The depth of injection is also influenced by the needle size and appropriate injection technique (for instance, flattening or pinching a skinfold). Correct landmarking of the injection site is just as essential to ensure optimal practice.

WEIGHT AND BODY MASS INDEX

Sebro identified a strong correlation between weight and BMI with the deltoid SC fat pad in both men and women.[25] The findings suggest that, as weight and BMI increase, there is a corresponding increase in the thickness of the deltoid SC fat pad. The increasing prevalence of obesity presents a significant challenge when administering IM injections, as longer needles may be required to reach the deltoid muscle.

In individuals with higher BMIs, a shorter needle may result in under-penetration, leading to decreased injection efficacy. White and colleagues conducted a retrospective review and found that, in most instances, IM medications were inappropriately administered, with needle length not determined based on BMI, resulting in a minimal possibility of true IM penetration.[24] It was found that appropriate needle sizes were more likely to be chosen when medication instructions were provided.[24]

Hemingway, Lui and White have advocated an assessment of obesity status before selecting length for IM injection in both genders.[27,25] They suggest that deltoid injections are more likely to achieve muscle penetration in people who are overweight or obese, independent of their gender.

The clinical implications of weight and BMI for IM injections are as follows:

- It is critical to make careful needle selections and update current immunisation guidelines to address this issue. While The Australian Immunisation Handbook currently recommends a 38 mm needle for very "large or obese individuals",14 this may not account for the individual BMI, leaving the choice open to subjective interpretation by clinicians. More specific guidelines based on patient BMI are needed to ensure accurate and effective delivery of IM injections.
- Deltoid injections are more likely to achieve muscle penetration in overweight or obese populations, independent of their gender.

Gender

Previous research has shown that gender differences exist in adiposity patterns, with females having thicker SC layers and thinner muscle layers than males with the same BMI.[28-30] This finding implies that a 25 mm needle may not consistently reach the deltoid muscle in heavier women. According to Sebro, a 25 mm needle was able to reach the muscle in only 85.3% of women weighing less than 90 kg and 98.6% of women weighing less than 118 kg.[26]

Injecting a vaccine that is intended for IM injection into the SC fat layer can lead to poor vascularity, resulting in slow mobilisation and processing of antigens. This has been shown to cause vaccine failure in diseases such as hepatitis B and influenza.[27]

The clinical implications of gender for IM injections are as follows (Table 2):

- A needle length of 25 to 32 mm is suitable for most adults (for instance, weighing 60 to 90 kg) for IM injections into the deltoid muscle. Patients who are emaciated require shorter needles for IM injections.
- Consider using a 38 mm needle for women weighing more than 90 kg or having a high BMI and for men weighing more than 120 kg.

TABLE 2. CURRENT INJECTIONS GUIDELINES VERSUS RESEARCH FINDINGS AND IMPLICATIONS

Recommended needle size, length, and angle for administering vaccines *Australian Immunisation Handbook* **(2023)**		
Age or size of person to be vaccinated	**Needle type**	**Angle of needle insertion**
Infant, child or adult for intramuscular vaccines	22–25-gauge, 25 mm long	90° to skin plane
Preterm infant (<37 weeks gestation) up to 2 months of age, and/or very small infant	23–25-gauge, 16 mm long	90° to skin plane
Very large or obese person	22–25-gauge, 38 mm long	90° to skin plane
Subcutaneous injection in all people	25–27-gauge, 16 mm long	45° to skin plane
Intradermal injection in all people	26–27-gauge, 10 mm long	5–15° to skin plane

Research findings with clinical implications on IM and SC injection practices	
Intramuscular injections (IMI)	**Subcutaneous injections (SC)**
• Increase awareness about variability in needle length and gauges, as relying on needle hub colour can lead to errors. Needles of the same hub colour can vary in length. Provide training and consider patient weight/BMI, gender, injection site, and medication type when choosing injection needles. **Gauge considerations** • For viscous/thick solution, use a wider gauge needle (e.g., 21G green hub) for smoother solution flow. Tissue irritation can occur when injecting a solution into the skin at high pressure with a smaller bore needle (e.g., a 25G orange hub needle). • For IM injections in infants, use a 23G or 25G needle to ensure better medication dispersion. **Length considerations** • Needle range from 25-32 mm is appropriate for most adults (e.g. 60-90kg) for deltoid IM injections. Consider using a 38 mm needle for women weighing more than 120kg. • Bunching technique (squeezing) with a 25 mm needle, to be used for deltoid IM injections in non-obese older adults, to avoid overpenetration of deltoid muscles and hitting the bone. • Use needles longer than 37 mm for gluteal injection in all females but avoid gluteal injections in obese females. • Ultrasound-guided and correct needle length selection improve accuracy. • In obese patients, consider using the thigh for IM injections if needle stocks are limited. • Deltoid injections are more likely to achieve muscle penetration in overweight or obese individuals, regardless of gender.	• Insufficient SC tissue/muscle mass may result in unintentional penetration into bone, leading to discomfort or osteomyelitis. This risk increases with longer SC needles, often due to the clinician's limited understanding of needle lengths. Refer to Figure 1. • Longer needles increase the risk of inadvertent IM injections, causing variable absorption and potential adverse effects, even with 13 mm needles. Risk is lower with 5 mm needles in children. • Techniques like the raised skinfold method can help reduce the risk of inadvertent IM injections. • BMI predicts skin-to-muscle depth, influencing absorption rates and increasing adverse effects. For immunotherapy, consider a 4 mm needle at a 45-degree angle to minimise inadvertent IM injections. • The disparity in recommended needle lengths persists, especially between diabetic and nondiabetic populations, adults/versus paediatric population, highlighting the need for updated guidelines. • Shorten pen needles (4 or 5 mm) are as effective as longer needles without increasing insulin leakage. • Manufacturer to redesign their product packaging for easier identification of needle length and measurement unit. • Urgent need for updated guidelines and further research to determine optimal needle length for different patient populations and injection sites, based on scientific evidence.

- Tollefson and Hillman recommended selecting a needle length that is half the width of the skinfold when it is pinched at the injection site.[28]

Anatomic site of injections

Dorsal and ventral gluteal sites

Several studies have reported low success rates for IM injections at dorsal and ventral gluteal sites, with drugs often being delivered into SC tissue instead of muscle, leading to reduced bioavailability.[29, 30] The problem is further compounded by the increasing obesity of people in all developed and many developing countries. This situation is particularly pertinent in the case of administering long-term depot antipsychotic injectables, where improper injection techniques can lead to impaired absorption, therefore, leading to poor control of symptoms for the intended duration.[31] This concern is heightened in patients with metabolic syndrome, many of whom are obese.[32]

Hemingway, Lui and White recommend for needles longer than the standard 37 mm at both gluteal sites, independent of obesity status. Injections into gluteal sites should be avoided in females who are obese.[25] Strohfus and colleagues conducted a systematic review and recommended the use of ultrasound-guided IM injections when the depth from skin to muscle was uncertain.[11] Proper landmarking and appropriate needle length were crucial for ensuring accurate IM injection placement.

Vastus lateralis site

Zaybak and colleagues conducted a study using sonography to measure the thickness of SC tissue in the dorsogluteal muscle and thigh.[23] They found that the SC tissue was thicker at the dorsogluteal site than in the thigh. The study concluded that a standard needle was effective for IM injections in the rectus femoris and vastus lateralis sites for all men and 77.8% of women. However, for individuals with a BMI greater than 24.9 kg/m^2, a standard 38 mm needle may not reach the muscular tissue at the dorsogluteal site.

The clinical implications of the anatomic site of IM injections are as follows (Table 2):

- Use needles longer than 37 mm for gluteal injection in all females but avoid gluteal injections in obese females.
- Proper landmarking and education are crucial for dorsogluteal IM injections.
- Ultrasound-guided and correct needle length selection improves accuracy.
- In obese individuals, utilising the thigh instead of the dorsogluteal site may be an option, particularly when needle stocks in the ward are limited.

NEEDLES FOR SUBCUTANEOUS INJECTIONS

In an SC injection, medication is injected into the fatty layer of tissue just beneath the skin (Figure 3). Medication injected into the SC layer is absorbed into the bloodstream more slowly than medication given by intravenous infusion or IM injection, and it therefore has a longer-lasting effect. Common medications administered subcutaneously include insulin for diabetes, anticoagulants for blood clot prevention, growth hormones, vaccines, and certain biologic therapies for conditions, such as, rheumatoid arthritis or psoriasis. Injections are typically given in the abdomen, thigh, or upper arm and have smaller volumes than IM injections.

The SC route is also used for the administration of local anaesthetics and drugs used in palliative care, such as fentanyl and morphine.

Typically, the needle for an SC injection ranges from 25G to 31G, and the length can vary from 4 to 16 mm. In general, shorter and thinner needles are preferred for SC injections to reduce the risk of accidentally injecting the medication into muscle tissue or a blood vessel.

REASSESSING THE LENGTH OF SUBCUTANEOUS NEEDLES: WHICH ONES ARE TOO LONG FOR OUR PATIENTS?

The effectiveness of SC injections is significantly impacted by the needle length used. The thickness of SC tissue varies based on the patient's body composition and the injection site, and it can impact the medication's absorption rate and efficacy. A poor understanding of the technique could result in the accidental administration of an intended SC injection into muscle tissue, and this could negatively impact the rate of absorption and potentially harm the patient. Cook highlighted that in rare cases when there is insufficient SC tissue and/or muscle mass, a needle can inadvertently penetrate bone or osseous tissue.[33] This can lead to discomfort due to a bony contusion or, in more severe instances, osteonecrosis. The risk of these complications is heightened when clinicians unknowingly use a longer SC needle because of a lack of knowledge about needle lengths and unfamiliarity with recognising needle length information on packaging.

Research has been ongoing for several decades on the appropriate needle length for SC injections, particularly for insulin delivery for diabetes management. Early imaging studies in the 1980s raised concerns about needle lengths being longer than the measured depths of SC tissue at different body sites, leading to an increased risk of inadvertent IM injection and subsequent variability in insulin absorption.[38] Recent research by Liyanage and colleagues has shown that there is still a high risk of inadvertent IM injection with currently used needles, particularly 13 mm needles; the risk of inadvertent IM injection was approximately 60% with 13 mm needles without a skinfold at the arm and thigh.[34] Kodikara and colleagues found that the risk of inadvertent IM injection was high with 15 mm needles and low with 5 mm needles in the paediatric population.[35] Regardless of the needle length used, the raised skinfold technique was associated with a reduced risk of inadvertent IM injection. Other studies have also shown that shorter pen needles (for example, 4 or 5 mm versus 12.7 mm) do not affect efficacy or insulin leakage, regardless of BMI.[36] The International Scientific Advisory Board for The Third Injection Technique Workshop released recommendations for best practices for injection techniques for patients with diabetes. It concluded that 4 mm pen needles were efficacious in all patients irrespective of BMI.[37]

An ultrasound study conducted by Kim and colleagues found that most patients receiving SC allergen immunotherapy had a skin-to-muscle depth less than the standard allergy syringe needle length of 13 mm.[38] This poses a risk of IM injection and an increased risk of anaphylaxis. To mitigate this risk, the authors recommended using a short 4 mm needle at a 45-degree angle to the skin. Additionally, the study showed that BMI was a significant predictor of skin-to-muscle depth, leading to inconsistent absorption rates and an increased risk of adverse effects.

The clinical implications of needle length for SC injections are as follows: (Table 2)

- Using a needle length that is longer than necessary can result in inadvertent IM injections, leading to variable medication absorption and potential adverse effects. The risk of inadvertent IM injection was high with 15 mm needles and low with 5 mm needles in the paediatric population.
- Studies have shown that shorter pen needles, such as those of 4 or 5 mm, can be as efficacious as longer needles without affecting insulin leakage.
- Techniques, such as, the raised skinfold method, may be employed to reduce the risk of inadvertent IM injections.

ARE CURRENT SUBCUTANEOUS INJECTION GUIDELINES IN THE AUSTRALIAN HEALTHCARE SYSTEM REFLECTIVE OF EVIDENCE-BASED PRACTICE?

To ensure safe and effective injection practices, healthcare professionals must have access to up-to-date guidelines and training. A search for guidelines on injection practices in Australia, by Annersten and Willman, showed that the available information was "spotty" and inconsistent and that some guidelines were not aligned with the scientific data that has emerged from decades of research.[39] Inconsistent guidance on SC injection techniques was found across various sources, such as, course literature, patient education pamphlets, and instructional leaflets.[39] The review examined 38 relevant articles from three databases, all of which emphasised the significance of the quantity of SC fat and the appropriate needle length in ensuring accurate drug delivery to the intended target tissue. However, the scientific evidence supporting the technical performance of SC injection is limited, highlighting the need for additional research in this area. Due to the lack of consistency, clinicians are often left to rely on their judgment when it comes to injection practices.

The available guidelines, such as, those from The Australian Immunisation Handbook [14] (Table 2), the Becton Dickinson (BD) Principles of Injection Technique,[40] and the Australian Diabetes Educators Association (ADEA), offer some recommendations on needle length selection for different injection types. The ADEA's Clinical Guiding Principles for Subcutaneous Injection Technique has published a comprehensive chart on needle length selection for insulin injection, and generally, shorter needle lengths are recommended (for instance, 4 to 6 mm).[41] BD recommends a needle of 4 to 13 mm (for instance, 29G to 32G) for insulin delivery and a needle of 13 to 16 mm (for instance, 26G to 31G) for other injections at a 45- to 90-degree angle of injection. The Australian Immunisation Handbook provides guidelines for SC injection using a 16 mm needle for all adults and children at a 45-degree angle to the skin.[14] There is no option for smaller needles to accommodate various patient characteristics. The handbook does not mention the use of the skin pinch-up technique or raised skinfold for individuals with less SC fat or paediatric patients, which reduces the risk of IM injection. However, it is important to note that evidence regarding SC injections suggests that a 16 mm needle, even when administered at a 45-degree angle, may be too long.[34-36, 38] This raises concerns about the potential risk of inadvertent IM injection. Further research is needed, particularly on the adult and paediatric populations, to thoroughly investigate and understand the optimal needle length for SC injections.

Taking into consideration factors, such as, age, physical condition, and medication requirements, it is evident that there is still a significant disparity in recommended needle lengths, particularly between diabetics and nondiabetics (assuming we are all the same physiologically). This highlights the need for further research and the standardisation of guidelines.

The clinical implications of evidence-based practices for SC injections are as follows:

- Risk of IM injections: The current recommended use of a 16 mm needle even at a 45-degree angle for general SC injections and immunisations raises concerns about the risk of inadvertent IM injections.
- There is a need for the updated standardisation of guidelines from various agencies and for further research to determine the optimal needle length for SC injections in different patient populations and at different injection sites.

SUMMARY OF CONSIDERATIONS FOR SUBCUTANEOUS INJECTIONS

In conclusion, the length of the needle used in SC injections is an important factor that significantly impacts the effectiveness of medication delivery. Accidental injection into muscle tissue or bone can occur when a longer needle is used. The available guidelines in the Australian healthcare system are inconsistent and may not reflect current evidence-based practices. Inconsistencies in guidance on SC injection techniques and needle length selections pose challenges for healthcare professionals, who are left to rely on their judgment.

CONCLUSIONS AND RECOMMENDATIONS

Administering injections is a critical nursing responsibility requiring extensive knowledge and expertise in techniques, needle selection, medication requirements, and potential complications. Despite decades of research contradicting traditional practices, many nursing practices and textbooks still recommend outdated methods, leading to confusion due to inconsistent guidelines for intramuscular and subcutaneous injections.

The current reliance on needle hub colour coding (typically "blue" for IM and orange for SC injections amongst nursing/medical professionals), rather than understanding how to interpret needle packaging information (with the same colour hub coming in various lengths, thereby causing error and confusion), is a concerning practice. Encouraging manufacturers to prioritise packaging design with prominent labelling for a clear visual representation of needle length can aid clinicians in selecting the appropriate needle, thereby reducing injection errors.

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Discrepancies in injection practices across healthcare settings pose potential risks to patient safety with unwarranted adverse reactions and suboptimal efficacy of medications being administered. Proper needle selection in terms of length and gauge, combined with correct injection technique, is essential for effective injections. This process also requires consideration of medication properties, such as, viscosity and pharmacokinetic features (for instance, long-acting depot), along with patient-specific factors like weight, BMI, gender, and the chosen anatomical sites.

In choosing the correct gauge for thick/viscous solutions, a wider bore needle (for example, green hub) is indicated, to reduce localised tenderness and erythema.

The weight and BMI of the patient influence the needle length, with individuals with high BMIs potentially requiring longer needles for proper muscle penetration. Gender differences in adiposity patterns should be considered, as longer needles may be needed to reach muscles in females than in males with the same BMI. It is also important to consider longer needles for dorsogluteal and ventrogluteal sites due to the presence of a significant amount of SC tissue in these areas. Ultrasound guidance and accurate landmarking can enhance injection accuracy.

To accommodate the diverse needs of patients, it is just as crucial to ensure that healthcare facilities maintain an adequate stock of needles of various lengths. Clear labelling and good stock organisation are essential to minimise confusion and ensure the correct selection of needles.

Furthermore, proper training of healthcare professionals is paramount. Educational institutions should integrate comprehensive programs to equip staff and students with the necessary knowledge and skills in injection practices. After all, the art of injection is part of our "bread and butter", and we should be familiar with the "tools" we use.

Governing bodies, such as, the Australian Technical Advisory Group on Immunisation (ATAGI) and the National Safety and Quality Health Service (NSQHS), should adopt evidence-based guidelines on needle length and gauge for IMI and SC injections. These guidelines should reflect the research findings from the last two decades to ensure both safety and efficacy. Interventions, such as, evaluating the effectiveness of educational programs and implementing quality improvement initiatives, could significantly enhance injection safety and accuracy. Future research endeavours could delve deeper into areas critical for optimal injection practices.

LIMITATIONS

The scope of the literature review may be limited, potentially overlooking relevant studies that could influence the findings. Time constraints may have prevented a comprehensive analysis of all relevant factors. While we discuss the impact of needle length and gauge, the precise identification of injection sites and correct injection techniques (for instance, Z-track versus skin bunching) and their implications for injection efficacy and patient outcomes warrant further investigations. The interplay between the aforementioned factors presents another intriguing aspect that could impact injection success. Further research exploring these interactions is essential for developing more comprehensive and effective guidelines. It is too expansive to explore fully within this study. Additionally, subjective interpretations by the writer may introduce bias, as the paper could selectively emphasise certain findings or overlook contradictory evidence.

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