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Intramuscular Injection Guideline Revisions are Needed Based on Body Mass Index, Needle Length, Sex, and Skin to Muscle Depth

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ABSTRACT

Background: Medications and vaccines are delivered via intramuscular injection throughout the world to improve health and to prevent or treat illness. Intramuscular injections are an essential nursing and pharmacist skill which includes choosing an appropriate injection site and selecting needle lengths and gages based on weight and muscle mass. Scientific evidence suggests changes in current practice and national guidelines to fully reach medication and vaccine efficacy.

Results: There is a direct relationship between medication/vaccine efficacy and health outcomes. The variance in weight provides vital information on the needle length and site of injection. Body mass index, age, sex, and skin to muscle depth are important measures when choosing the right needle length and site for an intramuscular injection.

The literature draws attention to deltoid injection concerns. The standard 25 mm needles may not be appropriate for small or large and obese populations as there can be reduced efficacy if the medication or vaccine is not deposited into the muscle. Other concerns include medications and vaccines deposited in the shoulder bursa in some patients instead of the deltoid pad causing pain, limited range of motion, and long-lasting disabilities.

Dorsogluteal and ventrogluteal sites are used for deep gluteal muscle injections. The ventrogluteal is the most appropriate site for deep muscle injections yet many nurses prefer the dorsogluteal site because of preference/comfort with the procedure. Deep gluteal injections often require longer needles to reach the muscle mass in large or obese patients, especially women.

Intramuscular injection guidelines are followed by clinicians worldwide. Agencies/centers such as the Centers for Disease Control and Prevention update these guidelines as needed but most national guidelines lack specific intramuscular injection instructions. Clinicians usually perform clinical procedures taught in basic training and follow national guidelines rather than performing individual clinical assessments.

Conclusion: Improving public health is vital, especially in various weighted populations that may not be receiving optimal efficacy of medications and vaccines. Updates to guidelines and continuous education and training in injection techniques should be a priority in all health agencies worldwide.

Keywords: intramuscular injections, needle length, body mass index or BMI, adults.

Introduction

An estimated 16 billion injections are administered annually.[1] Of these, five percent are vaccines delivered via injections. The other 95% of injections administered are medications, curative medications, blood products, alternative therapies, etc. The various injection routes are intradermal (ID), intravenous (IV), subcutaneous (SC), intraosseous (IO), and intramuscular (IM). This comprehensive review was limited to adult intramuscular injections, including vaccine administration over the last five years.

Medication and vaccine efficacy is dependent on IM injection delivery into the muscle. Ineffective or reduced benefit from vaccines or medications could be a risk for certain populations resulting in poor health outcomes and health disparities.[2-3]

Intramuscular injections may not reach the muscle in various populations due to the needles not being long enough or the injection is misplaced; the concerns are two-fold, one, the clinicians may not have updated evidence-based education on injection procedures, and two, the national guidelines for intramuscular injections are not specific enough for accurate placement into the muscle.

The Centers of Disease Control and Prevention (CDC), World Health Organization (WHO), and other national agencies provide injection guidelines for clinicians.[1,4-7] Unfortunately, not all guidelines reflect current evidence specific to needle length, age, weight, body mass index (BMI), or injection site consideration. As a result, large or obese populations especially women receive subcutaneous injections instead of intramuscular injections from too short of a needle used.[8] Conversely, elderly and small-framed adults may receive injections into the bone or misplaced in the subcutaneous tissue from too long of a needle. Adding to this problem of inadequate needle length, autoinjectors (standardized injectors) are a one size fit all for various weighted populations and may not reach the muscle to deliver medications including epinephrine in a life threatening event.[9]

The aim of this review is to provide an evidence-based appraisal of intramuscular injection processes and effectiveness in the deltoid, ventrogluteal and dorsogluteal sites in order to guide clinicians' administration of medications/vaccines to the right site, with the right sized needle, to the right muscle based on BMI, age, sex, and skin to muscle depth. Scientific evidence from this comprehensive review highlights procedural and assessment changes required in education and national guidelines worldwide.

This paper is organized as follows: Section 1 reviews effectiveness of medications and vaccines; Section 2 reviews deltoid intramuscular injections; Section 3 reviews single use and auto injector syringes/needles; Section 4 examines dorsogluteal and ventrogluteal intramuscular injections; Section 5 reviews national and worldwide agency guidelines as related to intramuscular injections; and Section 6 summarizes conclusions and limitations of this study.

Results

SECTION 1: EFFECTIVENESS OF MEDICATIONS AND VACCINES RELATED TO INTRAMUSCULAR INJECTIONS

Intramuscular injection strategies are important to consider and vital to the maximum efficacy of the medication/vaccine delivered. There are several body sites for intramuscular injections, deltoid (upper arm), vastus lateralis (thigh), dorsogluteal and ventrogluteal (buttocks). Typically, 1 ml or less of vaccines or medication can be deposited into the deltoid muscle. Larger amounts or more viscous medications are delivered into larger muscle masses such as vastus lateralis, ventrogluteal, or dorsogluteal injection sites. Medication efficacy is directly related to depositing the medication or vaccine into the muscle versus the subcutaneous tissue as muscle tissue is more vascular and medication is absorbed more quickly. Proper placement of the injection needle into the muscle by the clinician eliminates the injection as a cause of reduced efficacy of medications or vaccines.

Some vaccines and medications have reduced effectiveness or are rendered ineffective based on intramuscular injection placement resulting in various populations having a lowered therapeutic response and a higher risk for illness.[2-3,8-10] In the last five years, many vaccines/medications have lowered immunity or effectiveness including SARS-CoV-2, COVID 19,[2-3,8] epinephrine,[9] and mental health antipsychotic injections.[10] Lowered vaccine response in obese populations have been increasingly noted with the preponderance of higher mortality and chronic illness rates.[8] There is a 16% obesity percentage in the world with the United States ranking 10th in world obesity percentages at 41.64% of the total population.[11] Most recently there are studies identifying obesity/high BMI as a hindrance to vaccine and infection immune response.[3,8] These studies show correlations between body weight and type of medication or vaccine and medication/vaccine efficacy.[2-3,8-10]

SECTION 2: DELTOID INTRAMUSCULAR INJECTIONS

The deltoid subcutaneous fat pad is an anatomical measurement that should be used when calculating needle selection for intramuscular injections. The correlation between the deltoid fat pad thickness and various biometric data such as weight and BMI, and the implications of needle length selection for vaccination administration are important to consider.[12] The placement of the intramuscular injection in the deltoid is calculated at 4 cm distal to and in line with the posterolateral corner of the acromion process.[13] In addition to the placement of the injection, it is important to choose the right needle length to reach the muscle. Three different deltoid sites for intramuscular injection were evaluated resulting in standard needle lengths of 25 mm (1 inch) may not inject medication/vaccine into the deltoid muscle in a substantial proportion of adults with obesity.[14] The COVID-19 vaccination instructions recommends using a standard needle length of 25 mm (1 inch) which may not be long enough to deposit vaccine into the muscle in large or obese populations.[15] Current CDC and other injection guidelines for deltoid intramuscular injections may result in subcutaneous injections and potentially decrease medication/vaccine efficacy in women and obese

individuals.[12] Obese populations may not be optimally treated for life threatening illnesses due to clinicians using too short of needles causing health disparities within the delivery of care.

One study has found measuring the upper arm circumference may serve as a predictor to use longer needles than 25 mm (1 inch) for deltoid injections. In men with 35 cm and women with 30 cm circumference using a longer needle is recommended, specifically a 38 mm (1.5 inch) needle.[15] The CDC recommends women over 200 pounds and men over 260 pounds receive injections with greater than a 25 mm needle.[5] Using BMI as an index rather than weight alone could capture the variety of body shapes and skin to muscle depth, especially in large or obese women. More recent studies specify women with BMI 30 and above, and men with 35 BMI and above require 38 mm needles (1.5 inch) for deltoid injections.[2] Inadvertent subcutaneous injections may happen if one used too short of needles or skin is bunched. If the deltoid subcutaneous tissue is bunched there could be 20 mm added on to the depth of injection.[16] Some clinicians bunch the skin routinely in various sized patients due to traditional practices. Bunching the skin for an intramuscular injection is only needed in elderly or very thin adult patients to ensure vaccine is deposited into the muscle.

Vital to safe injection procedures is the placement of the deltoid injection far enough below to not injure the bursa of the shoulder joint.[12,17] Too many shoulder injuries related to vaccine administration have been noted by injections being given too high on the arm.[18-20] Shoulder injuries from an IM injection is characterized by shoulder discomfort and reduced range of motion after an IM injection, most often a vaccine-related injection.[18] This is caused by a vaccine administration from a clinician who lacks procedural education and training. It is important to be 4 cm below the acromion process before injecting any medication or vaccine into the deltoid. Improper placement can render a vaccine or medication ineffective and cause secondary injuries.

SECTION 3: SINGLE USE AND AUTO INJECTOR SYRINGES/NEEDLES

Single use auto disposable syringes come with a standard 25 mm (1 inch) needle for vaccine administration. Single-use syringes reduce cross contamination; those syringes with safety features significantly reduce healthcare worker needle sticks. The WHO 2025[21] strongly advises education and training with all injection devices and appropriate disposal to reduce both reuse and needle sticks. Changing the needle in an auto disposable syringe is not advisable due to increased risk of needle sticks, so many clinicians use the 25 mm needle regardless of weight, age or sex of the individual patient. Alternatively, it is best to prepare an adequate supply of 38 mm (1.5 inch) needles for those patients who are overweight or obese. Prefilling syringes with 38 mm (1.5 inch) needles, prescreening and labeling patients who need a longer needle, training staff with proper injection techniques and approaching patients in a non-stigmatizing way ensure proper deposit of the vaccine into the muscle are important preparations, especially in a mass immunization clinic.[2]

Auto-injectors (prefilled syringes with needles attached) deliver various medications including epinephrine in emergent situations (for anaphylaxis). If the medication is delivered into the subcutaneous tissue the treatment may be ineffective.[22] The standardized needles are one size and length; therefore, the needles may not eject through the skin thickness and reach the muscle in various sized adults. Bioavailability of epinephrine and other lifesaving drugs is dependent on several factors including needle length to ensure injecting into muscle.[9] There is a risk of either intraosseous or subcutaneous placement with autoinjectors in small or large populations.

Emergent situations with various sized patients with a one size fit all needle injector can be life threatening. Clinicians need to be prepared for alternate routes for emergency medications, especially in large or obese populations.

SECTION 4: DORSOGLUTEAL AND VENTROGLUTEAL INTRAMUSCULAR INJECTIONS

In clinical settings, the injection site is usually chosen according to the clinician's preference and comfort in administration. The ventrogluteal site is the recommended site for intramuscular injections into a larger mass of muscle as the subcutaneous tissue is thinner and the muscle tissue is thicker.[23] The landmarks and depth of muscle are more predictable and without nerves and major blood vessel interference. However, the dorsogluteal injection site is more widely used for intramuscular injections due to the comfort level of the clinician and the education and training received. Ventrogluteal is used less due to lack of training and knowledge. In a recent study nurses preferred the dorsogluteal site (88.5%) for IM injections over the ventrogluteal site (7.5%).[24] Reasons for the dorsogluteal is 'more used to it' (30.5%), 'unfamiliarity of the ventrogluteal site' (27%), 'lack of adequate knowledge' (19.5%) and 'not knowing how to determine the site' (10.3%). When provided with structured clinical training, nurses perform ventrogluteal injections with increased clinical assessment and technique.[25]

A study measuring depth of skin to muscle in ventrogluteal site, needle lengths of 20-48 mm in thin women were recommended, 18-53 mm in normal weighted women, 29-62 mm in overweight, and 26-88 mm in obese women.[23] Needle lengths of 23-37 in thin men, 18-41 mm in normal men, 25-50 mm in overweight, and 17-82 mm in obese men were recommended.[23] Longer needles are preferred in overweight and obese women as the skin to muscle depth is greater than in men; most important is the individual consideration of BMI, thickness of the adipose tissue, and condition of the muscle when administering an IM injection. In elderly adults, dorsogluteal or ventrogluteal can be used but based on the subcutaneous thickness and depth of muscle, the ventrogluteal is the best site to use.[26]

Since there is an increased prevalence of obesity in patients with severe mental illness, the importance of injecting tranquilizers and antipsychotics with the right needle length is vital in acute and maintenance therapy.[10] In this study, magnetic resonance imaging of 224 women and 126 men were reviewed to measure skin to the gluteus medius muscle. The measurements were correlated with BMI, weight, and height by multivariate

analysis. Failure rate of ventrogluteal IM injection with a 38 mm (1.5 inch) needle was 71% of women with a BMI >30, and 60% in men with BMI >35. BMI was found to be a reliable biometric in guiding needle length for ventrogluteal IM injections.

Kilroy and associates conducted a literature review on dorsogluteal injections.[27] Their research received local practice approval for dorsogluteal injections if the drug insert, clinical need (patient activity or agitation), nursing judgment, and patient preference were justified. Highlighted was the need for education and training beyond nursing training, especially in mental health facilities. While the dorsogluteal injection site is not widely supported by the literature, the evidence does advocate the use in some circumstances such as acute mental health settings as it supports client choice, clinician preference, and includes trauma-informed care and safety.[28]

Body mass index is significant in evaluating the dorsogluteal and ventrogluteal injection sites, subcutaneous, and total tissue thickness ($p<0.05$).[29] Females have greater subcutaneous tissue thickness than men so the needle length should be adjusted accordingly as the muscle, subcutaneous, and total tissue thicknesses are interdependent with the injection site, sex, and BMI. Ventrogluteal is considered the safest site for intramuscular injections.[29-30] The dorsogluteal site is a safe second choice if given in the anterior superior iliac spine and coccyx (ASIS-C) site. Based on BMI, the needle size for ventrogluteal and dorsogluteal injections in obese, normal, and mildly overweight individuals should be at a minimum of 38 mm (1.5 inch) with clinician assessment.[29-30]

To ensure accurate delivery in the muscle and depth of injection, ultrasound guidance should inform clinicians skin to muscle depth in dorsogluteal and ventrogluteal injection sites.[31] Ultrasound guidance can help prevent sciatic nerve damage and ensure proper placement of the injection into muscle. If improperly placed, gluteal injection complications include bleeding at the injection site, hematoma, pain, abscess formation and tissue necrosis. Injecting into adipose tissue retains injected material for longer periods of time and increases the risk of adverse reactions.[17] Subcutaneous abscesses/nodes and calcification (most often medication deposits) can occur if the injection is administered in the subcutaneous tissue at either the dorsogluteal or ventrogluteal sites.[29] If the medication is not injected into the muscle, it may be ineffective or have a reduced effect.

A recent systematic review ascertained a 38 mm (1.5 inch) needle in normal and overweight men would reach muscle in both ventrogluteal and dorsogluteal sites.[30] In obese patients, a 50 mm may be necessary however using 50 mm (2 inch) needles may require more research in overweight and obese men and women.[30] Delivering medication via a 50 mm needles is warranted in dorsogluteal and ventrogluteal injections, but these needles may not be available in healthcare facilities.[31]

SECTION 5: NATIONAL AND WORLDWIDE AGENCY GUIDELINES

CDC intramuscular injection guidelines include weight of men at 260 pounds and women at 200 pounds for longer needle consideration.[32-33] These guidelines for needle length may lead to subcutaneous injections in women and obese individuals.[12] The intramuscular injection guidelines do not include biometric data such as various weights, BMI, age, sex, and skin to muscle depth. While BMI is used by the CDC as a metric for population health, and underweight, overweight and obesity measures, it is not used in the guidelines for intramuscular injections.[34]

Even though the CDC[32-34] recently updated their guidelines for vaccine practices, the evidence is still based on Poland (1997) and Zuchermans' (2000) studies.[35-36] Recent evidence calls for change in practice, however much of what the CDC bases their recommendations on are decades old studies and some lack recent robust scientific rationale.[17]

The Green Book (2012) in the U.K. recommends longer needles in larger adults but not specific to age, weight, or BMI.[6] The Australian Technical Advisory Group on Immunisation (ATAGI 2022) recommends a 38 mm needle in large or obese adults but is not specific to the individual, age, or weight/BMI of the individual.[4]

The Ministry of Health guidelines state "needle length is determined by the size of the limb and muscle bulk, whether the tissue is bunched or stretched and the vaccinator's professional judgement".[7] Additionally, if the patient is a very large or obese person, a 38mm (1.5 inch) needle is recommended with clinical judgment. The recommended sites are deltoid or vastus lateralis but restrict the use of dorsogluteal or ventrogluteal injection sites.

Body mass index, sex, and age-based guidelines for needle length selection are more accurate and can be standardized throughout national guidelines worldwide.[12] Many recent studies request clinicians' individual patient evaluation and a revision of the current national guidelines as they are a gold standard for nurses to follow.[23,17-19,37] Evidence-based standardization of this education at healthcare agencies worldwide is vital to public health outcomes.[17,24]

LIMITATIONS

Various studies found from different search engines created a heterogenous limited review. This search strategy may not have captured all published evidence in the last five years. Previous evidence in the last two to three decades was not included in this review; there are many valid studies on intramuscular injections before 2020. The limited research found in the last five years qualifies as additional and substantial evidence for practice change.

Section 6: Conclusion

There is an urgent need for updated intramuscular injection evidence-based guidelines prioritizing medication effectiveness, patient safety, and adherence. Body mass index, age, and sex should be taken into consideration as all are significant factors influencing skin to muscle thickness. Obesity is a critical factor that increases the risk of a subcutaneous injection due to using too short of needles to reach the muscle. The demographic groups, obese populations especially

women, are at higher risk of vaccine, medication, and epinephrine failures.

Several studies in this literature review highlight needed changes in intramuscular injection practices. These include using 1. BMI, sex, age, and skin to muscle depth as a standard to evaluate needle length and site,[2,12,14-15,37] 2. longer needles for intramuscular deltoid, ventrogluteal and dorsogluteal injections in large and obese female populations,[29,30] 3. longer needles for deltoid injections in obese men,[2,14-15] and 4. ventrogluteal as the preferred and safest gluteal site for intramuscular injections,[23] and dorsogluteal injection site may be used as a second choice relating to individual patient and clinician informed care.[27-28,31]

A deltoid injection based on the BMI/weight/sex of the individual is recommended. Accurate assessment of the injection placed 4 cm below the acromium process is essential to avoid vaccine or medication being deposited into the shoulder bursa.[13] Avoid skin bunching in normal, overweight and obese individuals and consider bunching of the skin/deltoid only if the patient is frail with a small deltoid mass.[18-20]

This review specifically requests the CDC, WHO, and other national experts to update intramuscular injection guidelines to include current scientific rationale. While Poland et al., (1997), provides a sound basis to evidence-based practice, it is time to update the evidence with current studies to guide injection practices and education worldwide.[35-36]

Schools of nursing and pharmacy also need to update their clinical training and education based on current scientific evidence. Healthcare agencies must offer continuous current education and training providing clinicians with the decision-making ability to determine needle length based on BMI and sex, appropriateness of the site, location of the muscle, and skin to muscle depth.

Eliminating intramuscular injections as a cause of ineffective or reduced therapeutic effects of medication and vaccines should be the priority of healthcare worldwide. Improving public health and safety is vital, especially in cases of various weighted populations who may not be receiving optimal benefits of medications and vaccines.

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