Subcutaneous insulin injection technique


Aims and intended learning outcomes

The aim of this article is to update general nurses' knowledge of insulin injections. The importance of choosing the optimal injection site for the prescribed insulin regimen and matching the site with the needle length and injection technique is discussed. The appropriate storage of injection devices between use, resuspension of cloudy insulins, and safe disposal of pen needles are also highlighted. After reading this article you should be able to:

- Provide evidence-based, individualised advice on the optimal injection sites and pen needle sizes for each patient and his or her prescribed insulin type and regimen.
- Explain what causes lipohypertrophy and lipoatrophy and how to prevent both.
- Update your colleagues and patients on recommended insulin injection techniques.
- Re-educate healthcare professionals and insulin users on the importance of resuspending cloudy insulin and the long-term adverse effects of needle re-use.

Insulin therapy was initiated during the 1920s and since then scientists have focused on producing newer and improved types of insulin in an attempt to mimic the physiological action of human insulin in a patient with diabetes. More recently, it has been proposed that the way the injection is performed is as important to good glycaemic control as the type and dose of insulin given (Partanen and Rissanen 2000, Strauss et al 2002a).

The techniques used for insulin injection contribute to variability and fluctuations in blood glucose control. In the UK, about 580,000 people inject insulin every day and many have been doing so for years or decades (Diabetes UK 2001). More patients now prefer multiple daily injections using a variety of devices, with the global trend in recent years away from syringe use and towards pens (NovoCare News 2000).

Large-scale studies have been carried out on optimal insulin regimens but little attention has been given to what the ideal needle length might be, how to pick injection sites appropriately, and how to avoid problems in injection areas. Use of modern ultrasound and magnetic resonance imaging (MRI) technology has revealed misconceptions about current injection practices (Strauss et al 2002a). Nurses play a crucial role as instructors in insulin administration and need to update and reassess their knowledge of relevant contemporary research findings.

Aims and intended learning outcomes

Importance of injection depth

To ensure the most reliable and consistent absorption of insulin, injections should be made into the subcutaneous adipose (fat) tissue rather than intradermally, intramuscularly, or intraperitoneally (Frid et al 1990, Pemberton and Holman 1989, Strauss et al 2002a, Thow et al 1990).

Several studies have demonstrated a difference in the absorption rate and duration of different insulins when injected into subcutaneous fat and muscle (Polak et al 1996, Thow et al 1990). Intramuscular injection speeds up absorption and can lead to unexpected hypoglycaemia which, especially in the very young and frail older people, may convey a major risk. Hypoglycaemia can lead to seizures and possible
Injection management

Cognitive impairment in the very young, and seizures, falls and consequent hypothermia and/or fractures in older people. The uptake of short-acting and intermediate-acting insulin is increased by at least 50 per cent in an intramuscular injection compared with a subcutaneous injection in the thigh, whereas the difference in the abdominal area is less significant. This is attributed to an increased blood flow in the subcutaneous fat in the abdomen compared with the fat in the thigh (Hanas 1998).

Other confounding factors, such as exercise and ambient/body temperature, have a greater influence on the rate of absorption if the insulin depot has ended in the muscle tissue rather than subcutaneous fat as a result of increased local blood flow and greater mechanical dispersal by contracting muscles (Thow et al 1990). Intradermal injections (that is, too superficial), on the other hand, can lead to leakage of insulin from the puncture site, sterile abscesses, increased pain, and enhanced immune reactions to insulin due to lymphocyte stimulation, and should be avoided (Strauss 1998a, Strauss et al 1999).

A significant factor in depositing insulin in the intended tissue layer is the length of the needle (Thow and Horne 1990, Uzun et al 2001). Until recently, recommendations for needle length have focused on the body mass index (BMI), gender and age of the person with diabetes (Strauss 1998a). Adults have been generally advised to inject at 90º to the skin using a two-finger ‘pinch-up’ technique to lift the skin fold away from the underlying muscle layer to increase the chance of subcutaneous injection (Figure 1). Holding of the skin fold should be maintained until the needle has been withdrawn from the skin. Injecting into a raised skin fold is thought to result in a more diffuse depot of insulin, in contrast to a compact circumscribed bolus injected without a pinch-up. Absorption may be affected by these different ways of distribution (Becton Dickinson 2001a, Strauss et al 1999). When injecting at 45º or into the buttock areas, which have the densest fat layer, lifting up the skin fold is not required (Wood et al 2002).

Recent ultrasound and MRI images of injection sites have shown that the average skin thickness (that is, epidermis and dermis above the subcutaneous fat layer) in the injection site areas varies between 1.5mm and 3mm and that the thickness is no more in obese patients than in lean individuals (NovoCare News 2000, Pemberton and Holman 1989). Hence, it can safely be recommended that most people injecting insulin, young and old, slim, average body weight, or obese, with type 1 or type 2 diabetes, can use 5mm or 6mm needles to deliver their insulin in the subcutaneous layer with much less discomfort or psychological fear than...
Injection sites

The recommended sites for insulin injections are abdomen, thighs and buttocks. In addition, at least a third of patients use the upper arm for injection at some time of the day, as it is often the most convenient part of the body to reach when injecting in public (Strauss 2002a). Until recently, it was assumed that the fat layer in the arm was relatively thin and health professionals would recommend arm injection only with the pinch-up technique – a nearly impossible manoeuvre to perform with one hand (Bantle et al 1993, Strauss 2002a, Wales 1997). Latest MRI findings, which enable the body parts to be viewed longitudinally as well as cross-sectionally, have revealed that the subcutaneous fat tissue thickens further down the arm laterally and posteriorly (Figure 2). Therefore, the short 5mm or 6mm needles can be safely used for arm injections in all adult patients without the pinch-up, provided the injection is given in the lower part of the upper arm, either in the lateral or the posterior aspect (Strauss 2002a and b).

Similarly, new insight has been gained into the injection areas in the thigh. Insulin is best injected immediately under the greater trochanter rather than the mid-shaft of the femur, as routinely advised until recently (Strauss 2002a) (Figure 3). The subcutaneous fat thins out rapidly when moving down the thigh and, understandably, many patients comment on the pain of injections and frequent bleeding at this site. As with the arm, the shorter 5 or 6mm needle is the choice for thigh injections without a lifted skin fold (Strauss 2002a).

Absorption from different sites Absorption is most rapid from the abdomen, somewhat slower from the arms, slower still from the thighs and

Insulin syringes

Although shorter pen needles have been available for several years, syringe users in the UK have been offered little choice until recently. The 100 unit insulin syringes only come with 12.7mm attached needles, whereas 30 and 50 unit syringes with the shorter 8mm needle are available in multipacks of ten for individual patient use in the community. In hospitals, where syringes have to be individually blister packed for infection control purposes, the two smaller sized insulin syringes have been recently introduced. It is important to remember that there are some people with diabetes for whom syringes are the only device on offer – those on Lente-type basal insulin. Crystalline insulins are not suitable for pen cartridges, where the mixing action of the glass marble would cause the insulin structure to break (Hanas 1998).

TIME OUT 2

List the insulin injection devices (pens, syringes, prefilled pens) you have encountered in your clinical area. You could contact a diabetes specialist nurse to obtain posters of these devices and ask for a demonstration of how to prime them and how to change cartridges and needles. You might also consult an illustrated guide, such as Diabetes UK (2002) or Wood et al (2002).
slowest from the hip or buttock area (Frid and Linde 1992, Williams and Pickup 1999, Wood et al 2002). These times, in turn, are affected by ambient temperature and clothing, as well as any rubbing or exercise that occurs around the time of injection (Wales 1997). Therefore, it is generally recommended that rapid and fast-acting pre-prandial insulins are given in the abdomen or thighs (Hanas 1998). As absorption from the buttocks is slow and more predictable, slow-acting bedtime injections are best injected in this site (Partanen and Rissanen 2000, Wood et al 2002).

The trouble with buttock injections is that they tend to be given in the same place because of difficulties in reaching the area, which can lead to problems of using the same injection site (discussed below). Combinations of fast and immediate-acting insulin could be given in the abdomen in the morning, or in the thigh or buttocks later in the day (Hanas 1998). Interestingly, in the case of the first real long-acting analogue insulin glargine, no significant difference has been found in the absorption rates for the different anatomical sites (Owens 2002).

The fat in the abdomen thins out rapidly when going laterally away from the umbilicus and hence increases the risk of intramuscular or intraperitoneal injection. The absorption is faster when injection is above the umbilicus than when it is below or on the side of the umbilicus (Frid and Linde 1993, Hanas 1998). However, healthcare professionals should encourage patients to use the entire anterior abdominal wall, above and below the waistline, for insulin injection, rather than a small area below the umbilicus, as often seems to be the case (Walker 2002). Such practice means that patients are injecting in the same area repeatedly, which leads to the formation of fatty lumps, called lipohypertrophies (Partanen and Rissanen 2000, Strauss et al 1998) (Figure 4).

**Rotation within injection sites** Since absorption varies from site to site, an injection at a certain hour should always be given in the same anatomical site to enable patients to predict the effect of a given dose (Hanas 1998). However, it is important to rotate within a site each day, moving one finger width from the site of the previous injection or alternating from left to right, to avoid the build-up of lipohypertrophies.

**TIME OUT 3**

Imagine you are looking after a 32-year-old patient with type 1 diabetes, whose glycaemic control has been deteriorating with unexplainable hyperglycaemic and hypoglycaemic episodes. You observe her injections and notice that she always injects into her left upper arm, which appears lumpy. How would you educate this patient about ‘lipos’ and their effect on glucose control?

Lipohypertrophies, or ‘lipos’, are caused by the growth factor effect of insulin itself and by local growth factors induced by the trauma of blunt, re-used needles (Diabetes UK 2001, Partanen and Rissanen 2000). Since the lipohypertrophic area proves to be a less painful injection site, patients are known to prefer injecting there. However, absorption of insulin from lipos can be slow and erratic, leading to an increasing daily requirement of insulin and deterioration of glycaemic control. However, the opposite can also happen (Guthrie and...
CONTINUING PROFESSIONAL DEVELOPMENT

Injection management

Guthrie 1997, Strauss et al 2002b). Hypoglycaemia often occurs when the injection usually given in the hypertrophied site inadvertently enters the normal subcutaneous fat.

Visual inspection and palpation of injection areas should be performed on all patients at every clinic visit, and patients instructed in regular rotation practice. In people who use animal insulins, lipohypertrophies – dimple-like indentations – tend to be more common. Lipohypertrophy and atrophy are seriously underestimated and increasing problems of insulin therapy, possibly resulting from the high number of injections many people with diabetes now perform (Kordonouri et al 2002, Partanen and Rissanen 2000).

Minimising painful injections

The least amount of discomfort is experienced when the injection is made with a sharp, short needle penetrating the skin quickly without any drag – the needle piercing taut skin – and when the insulin is at room temperature (Hanas 1998).

The long-term effect of multiple daily injections over a patient’s lifetime cannot be ignored. Needles are now shorter, finer in diameter (the greater the gauge number the smaller the diameter), have thinner walls but wider bores, and are coated with silicon lubrication to minimise local tissue trauma (Burtenshaw 2002, Novo Nordisk 2000). This means that they have also become more delicate and prone to bending and even breaking, and should not be used more than once (Figure 5) (Strauss 2002b).

A needle loses a significant amount of its sharpness and silicon lubrication in the process of first piercing the stopper of an insulin vial. Because a pen needle is not pushed through the rubber stopper of an ampoule before injection, new pen users often report less pain on injection compared with syringes (Fleming 2000). With re-use, the tip bends and forms a hook, which may even break off inside the skin. Bending can occur at the needle tip (microscopically) or at the hub (macroscopically) and both are implicated in the breakage of the needle. The patient may not even be able to see the bending with the naked eye (Strauss 2002b).

To avoid pain, bruising and unsightly lipohypertrophies, needles should not routinely be re-used. Nurses, doctors and patients may be to blame for inadvertently encouraging this unsafe habit. Misleading statements, such as the following by the American Diabetes Association, appear to condone, even endorse, the re-use of needles: ‘Some patients find it practical to reuse needles. Certainly, a needle should be discarded if it is noticeably dull or deformed...’ (ADA 2002). Since March 1 2000, patients with diabetes have been able to obtain pen needles free on prescription in the UK, and hence the financial costs are no longer levied on individual users.

Resuspension of cloudy insulin

Cartridges and vials with cloudy insulins contain a predetermined ration of neutral protamine Hagedorn (NPH) insulin and a clear solvent or mixtures of NPH insulin and a short-acting soluble insulin (Jehele et al 1999). It is vital that the two-phase solution is

Figure 3. To maximise probability of a subcutaneous injection, insulin should be injected just below the greater trochanter and not at the mid-shaft of the femur

(MRIs performed by Dr Anders Frid, Lund, Sweden. Reproduced by permission of Becton Dickinson)

Figure 4. Lipohypertrophy of an abdominal site

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Injection management

CONTINUING PROFESSIONAL DEVELOPMENT

Box 1. How to use a pen to give an injection

1. Wash hands
2. Check expiry date on cartridge and amount of insulin left
3. Fit a new pen needle
4. Turn pen up and down 20 times
5. Remove outer cover and inner cap of needle
6. Dial two to four units to insulin left in cartridge and amount of insulin left
7. Dial required dose
8. Stretch skin taut/lift skin fold (whichever appropriate)
9. Insert needle smoothly into skin and press plunger (whichever appropriate)
10. When dose is given, count ten before removing needle from skin
11. Remove needle from pen and dispose in sharps box
12. Store pen in its case at room temperature, away from heat or sun

Figure 5. Pen needles should not be used more than once

New needle

Re-used needle

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Storage of insulin

The pain of injections can be minimised by maintaining the insulin at room temperature. Hospital nurses must be dissuaded from placing patients’ insulin pens and devices in a ward fridge. Insulin withstands room temperature well without losing any of its effectiveness (Hanas 1998). Using the same insulin cartridge or vial without refrigeration for up to two months is a safe routine and will minimise wastage (Hanas 1998). However, short- and rapid-acting insulins are said to be less stable than intermediate and long-acting insulins (Hanas 1998). Spare cartridges and bottles are best stored in the main body or the door of a fridge.

When travelling in a car in extreme temperatures, an insulin pen containing a cartridge should be kept away from the glove box, in an insulated cool bag or a thermos flask. The pen should never be stored in a fridge but in its case at room temperature away from sunlight, radiators or other sources of heat.

Those who re-use needles and keep the pen in the fridge between injections risk twofold hazards: insulin leaking out and air bubbles forming inside the cartridge. Moving the pen with a needle attached to a warmer temperature (out of a fridge or into a pocket on the body) will cause expansion of the fluid and leakage of insulin through the needle (Strauss 1998b).

Such leakage will result in crystallised insulin clogging the needle barrel and blocking the flow during the next injection. This is a particular concern with cloudy insulins. As the insulin is in the solid particles that sink to the bottom of the cartridge, the inactive solution will leak out of the needle if the pen happens to be stored with the needle upwards. The result is that the remaining insulin will become more concentrated. If the pen is stored upside down, the insulin-containing particles will settle closest to the needle and leak as the insulin warms; the remaining solution will then be more diluted (Hanas 1998). Inversely, moving the pen with a needle in place from warm to cooler...
Injection management

Figure 6. Resuspension of cloudy (NPH) insulin

A. Before mixing
B. After rolling the cartridge seven times
C. After rolling 20 times

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cal position, with the needles pointing upward, to prevent the suspended insulin particles from clogging the needle bore (ADA 2002).

TIME OUT 5
You are supervising a nursing student to prepare an injection of intermediate-acting human insulin with an injection pen.
He finds it in the ward fridge with a needle attached, dials the prescribed dose and asks you to check it. How would you educate him on the correct way of preparing this injection?

Injecting through clothing

Injection through clothing is practised by about a third of patients, especially teenagers, for reasons of convenience, when in a hurry, at parties or in public places where removing clothing is not feasible (Strauss et al 2002b). Inevitably, the passing of the needle through clothing, especially tough denim, will remove the silicone lubrication and blunt the needle, increasing pain and discomfort (Hanas 1998).

However, such practice on occasion is considered safe and without any major adverse effects. Although convenient, it is not advisable as a routine. Minor problems, such as bloodstained clothing and bruising, have been reported (Fleming et al 1997).

Disposal of pen needles

It is vital to dispose of pen needles safely. To unscrew the needle from the pen device (or twist it off) without causing a needlestick injury, the outer protective cap needs to be replaced to cover the needle.

This advice often comes as a surprise to nurses who are told never to resheath any syringes after use, but to remove the pen needle without the protection is virtually impossible. Great care must be taken when doing this. Appropriate recapping requires adequate vision and manual dexterity.

The pen device should be supported in the hand or on a level surface while the outer cap is replaced with a straight motion of the thumb and forefinger. The technique of guiding both the needle and the cap to meet in mid-air should be discouraged as this frequently results in unintended needle penetration (ADA 2002).

The used needle inside the outer cap, as well as lancets used in glucose monitoring, should then be discarded in a puncture-resistant sharps container. One brand of sharps bin is available on prescription for home use and patients should check with the GP surgery how to dispose of it when it is full. In some areas, this may be through returning

REFERENCES

Conclusion

Optimal injection technique is essential for good glycaemic control. A great deal of time and effort is often spent educating patients when insulin therapy is first initiated. However, when the patient has been performing the same procedure for years, details may have been forgotten, ignored and neglected. Recommendations and advice given by healthcare professionals need to be revised and updated as professional understanding of insulin deposition and absorption improves.

Every outpatient visit or inpatient contact should be used for review and updating of injection technique. Watching patients perform their injections is an important opportunity to identify difficulties or problems. Through a sensitive, non-critical approach, nurses can help the patient to understand his or her own role in reducing the effect of diabetes. Similarly, there is an urgent need to raise awareness of and disseminate updated guidelines among all staff involved in the use of insulin injector devices, their storage and disposal.

TIME OUT 6

Now that you have completed the article, you might like to write a practice profile. Guidelines to help you are on page 55.