Injection management

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Subcutaneous insulin injection technique

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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 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 2002a). Nurses play a crucial role as instructors in insulin administration and need to update and reassess their knowledge of relevant contemporary research findings.

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

In brief

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Summary
Insulin injection technique has far greater bearing on glycaemic control than is often recognised. This article discusses the optimal needle length for different injection sites and highlights other crucial aspects, such as needle re-use, importance of adequate mixing of cloudy insulin, and the way pen devices should be stored.

Key words
- Diabetes
- Diabetes: nursing
- Injections

These key words are based on subject headings from the British Nursing Index. This article has been subject to double-blind review.

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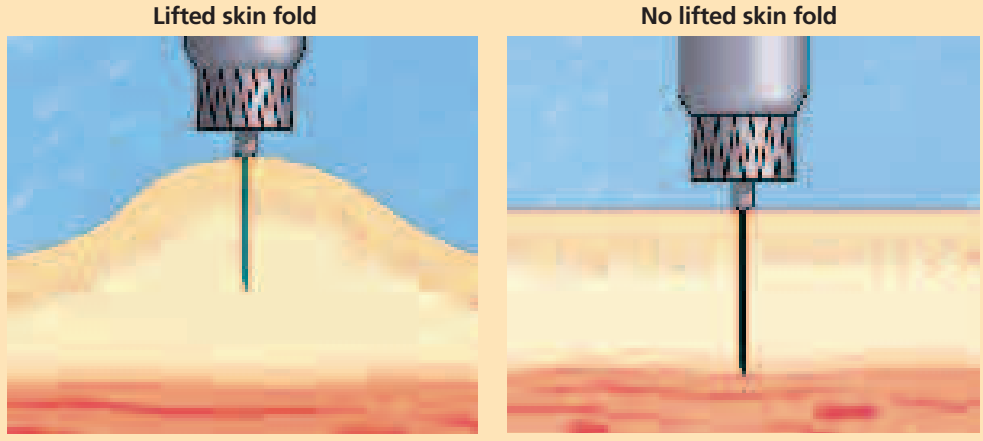
Figure 1. A raised skin fold increases the chance of subcutaneous injection



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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).

TIME OUT 1

Reflect on the training you have received in insulin injection technique and the way you have administered this drug to your patients. Do you involve the person with diabetes and adopt his or her practices in this procedure? Compare your technique with the following information.

Pinch-up or not?

A significant factor in depositing insulin in the intended tissue layer is the length of the needle (Thow and Home 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 90° 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 45° or into the buttock areas, which have the densest fat layer, lifting up of the skin fold is not required (Wood *et al* 2002).

Use of shorter needle length

Children and adolescents have usually been offered the choice of injecting with or without pinch-up, provided they use a shorter needle length of 5, 6 or 8mm (Smith *et al* 1991, Tubiana-Rufi *et al* 1999, Wales 1997). Similarly, many older insulin users would certainly benefit from shorter needles, as body fat distribution and skin thickness tend to diminish with age (Hendra 2001).

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

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when using longer needles (Chiarelli *et al* 2001, NovoCare News 2000, Solvig *et al* 2001, Strauss 2002a). With these ultra-short needles, there is no need to lift the skin fold, except in thin patients with BMI less than 20kg/m^2.

Since the aim is to inject into the subcutaneous fatty tissue, the main concern should not be how deep into the fat the needle tip reaches, but to ensure that it does not reach as deep as the underlying muscle layer. The evidence from absorption studies carried out in Sweden shows that absorption from superficial fat layers is the same as it is from deeper layers near the muscle fascia (Frid and Linde 1992). Therefore, there is no concern about variability in the absorption rate.

The shorter needles are also thinner in diameter/gauge (G31 instead of G30 or G29) and have a unique thin-wall design. This means that the bore is wider and this speeds up insulin flow and reduces resistance and, hence, the pressure needed to inject insulin from the device used (NovoCare News 2000, Novo Nordisk 2000). The lighter force needed to deliver a dose via a wide-bore needle is clearly an advantage for all users, resulting in less discomfort, but particularly for people with reduced manual dexterity or strength (Birkebaek *et al* 1998).

Pen use The faster flow of insulin during pen use means less dribbling from the pen tip on completion of the injection, and therefore a more accurate dose being given. It is, however, vital that the needle is always left in the skin for six to ten seconds after the plunger has been fully pressed down to ensure that the full dose is received (Annersten and Frid 2000, Becton Dickinson 2001a).

Among pen users, the 8mm needle has now overtaken the 12 or 12.7mm length and there are signs that the 5 and 6mm needles are on their way to becoming the standard length for people with diabetes (Strauss 2002a and b).

Furthermore, needles as short as 3mm might prove advantageous for children and for those wanting to inject at 90° on arm and thigh areas without a pinch-up. The pain of injection and fear of needles is rated to be significantly lower with the shorter needles (Strauss 2000).

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).

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 crystal structure to break (Hanas 1998).

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

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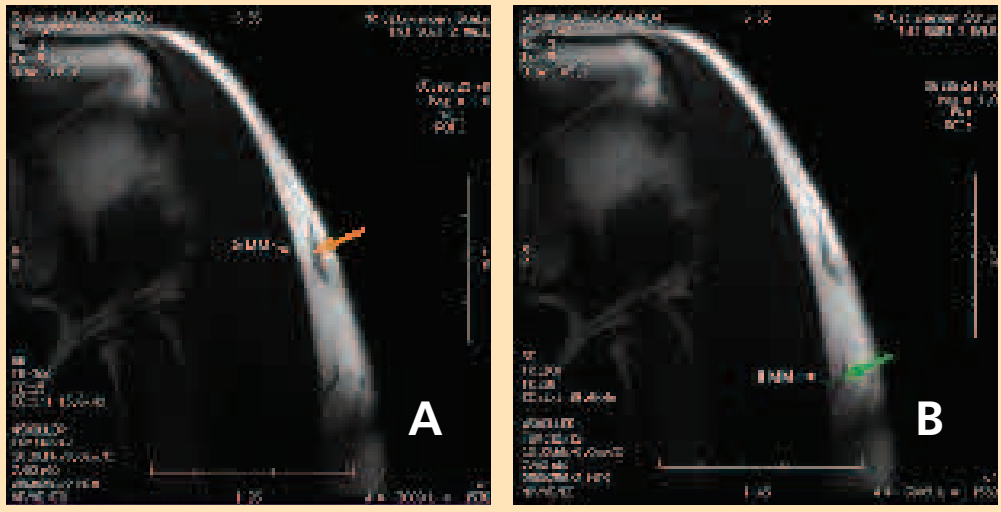
Figure 2. Arm injection without a raised skin fold using a 5mm (A) and an 8mm (B) needle



If an 8mm needle is used the injection should be given further down the arm and slightly posteriorly. (MRIs performed by Dr Anders Frid, Lund, Sweden. Reproduced by permission of Becton Dickinson)

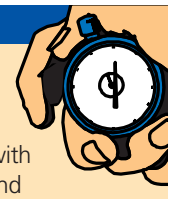
slowest from the hip or buttock area (Frid and Linde 1992, Williams and Pickup 1999, Wood *et al* 2002). These times, in turn, are affected by ambient temperature and clothing, as well as any rubbing or exercise that occurs around the time of injection (Wales 1997). Therefore, it is generally recommended 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

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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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, lipoatrophies – 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 piercing the skin, and in the case of a syringe, even more so 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 (Jehle *et al* 1999). It is vital that the two-phase solution is

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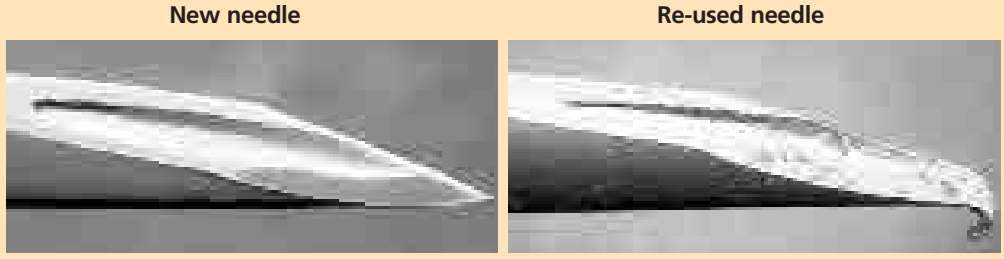
Box 1. How to use a pen to give an injection

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 perform airshot, repeat until insulin drop is seen
7. Dial required dose
8. Stretch skin taut/lift skin fold (whichever appropriate)
9. Insert needle smoothly into skin and press plunger
10. When dose is given, count to 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



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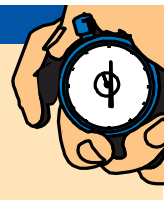
adequately mixed before each injection to re-insert the cloudy insulin into the suspension. Resuspension of cloudy insulin in cartridges has been found to be more difficult than in vials, possibly due to the lack of air (Jehle *et al* 1999).

Studies have shown that it is necessary to turn the pen device up and down at least 20 times before complete resuspension is obtained (Karch and Karch 2000) (Figure 6). This step is particularly important when a new cartridge is started or when the cartridge has been stored for a while. Inadequate remixing results in large clumps of aggregated NPH insulin flowing out during the first injection from a new cartridge. Such delivery of very highly concentrated insulin is likely to cause a subsequent dramatic hypoglycaemia (Strauss *et al* 2002b). The NPH content of a cartridge that has not been adequately mixed has been shown to range from 5 per cent to 214 per cent of the expected concentration (Jehle *et al* 1999). Such variability is bound to lead to both hypoglycaemic and hyperglycaemic events, worsening HbA_{1c} values, and to unexpected disruptions in the patient's lifestyle (Box 1).

Insufficient pen insulin mixing is surprisingly common in clinical practice. Patient and staff education must be continually updated and nurses should be especially vigilant with patients who have been performing the procedure for years. It is also important to point out that resuspension of cloudy insulins is easier when the insulin is at room temperature. Pens containing a cartridge in use should not be kept in the refrigerator – a common practice on hospital wards (Strauss *et al* 2002b, Wood *et al* 2002). Patients who transfer to the new long-acting insulin analogue glargine will find that this insulin is clear and does not require any resuspension.

TIME OUT 4

Reflecting on your practice, how often do you take adequate time to resuspend a cloudy insulin or instruct the patient to do so?



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

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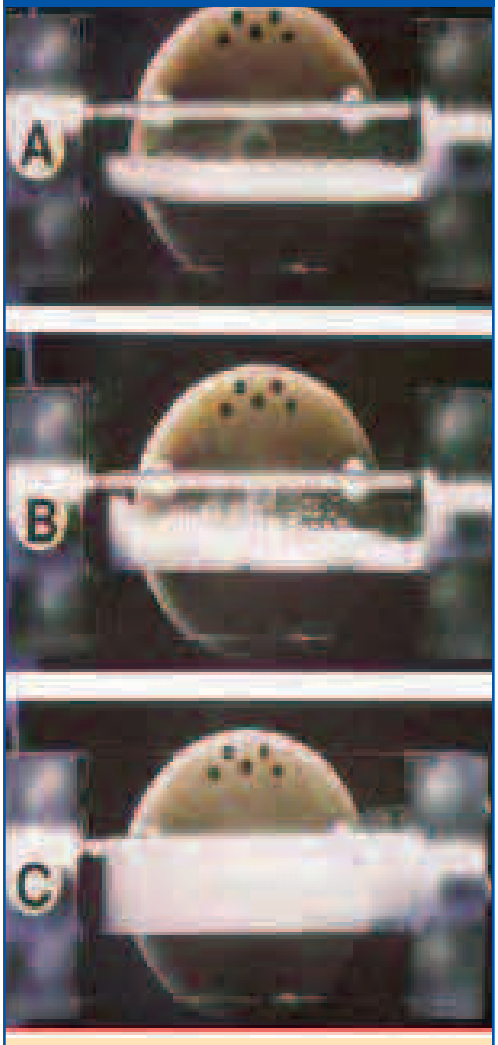
Figure 6. Resuspension of cloudy (NPH) insulin



A. Before mixing
B. After rolling the cartridge seven times
C. After rolling 20 times
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temperatures (indoors to outdoors in winter or from room temperature to a fridge) will cause contraction in the cartridge contents and air entry through the needle.

With trapped air bubbles inside the cartridge being compressed during an injection, the injection time becomes lengthened. The air bubble will cause no harm to the person injecting but the dose will be less than intended. Insulin will still continue to leak from the needle tip even after the ten-second countdown for removing the needle from the skin (Hanas 1998, Strauss 1998b).

People with diabetes who are dependent on others for drawing-up their insulin and use predrawn syringes should be instructed how to store them correctly. The syringes should be placed in a vertical 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

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Useful websites

- www.diabetes.org.uk
- www.diabetesonestop.com
- www.diabetesnursing.com
- www.doh.gov.uk/nsf/diabetes
- www.joslin.org
- www.diabetesresource.com
- www.diabetescare.warwick.ac.uk
- http://care.diabetesjournals.org/
- www.idf.org
- www.bddiabetes.co.uk

it to the surgery or pharmacy, in others through a collection by the local authorities against a small charge (Diabetes UK 2002). This practice needs to be unified throughout the UK to avoid confusion. Unfortunately, according to a recent Europe-wide study nearly half of insulin-injecting patients dispose of their needles directly into the household rubbish after clipping or recapping (Strauss *et al* 2002a). This is clearly a public health hazard, and nurses have a duty to reiterate the message of safe sharps disposal at every point of contact with patients. Even when the needle is clipped, the remainder should still be placed in a suitable sharps box. The habit of using empty plastic drink bottles to deposit used needles and lancets still means that they end up in landfill sites, which is to be actively discouraged.

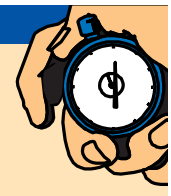
Conclusion

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.



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