Insulin use in patients with type 2 diabetes: problem solving

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In people with type 2 diabetes treated with insulin, problems can arise due to the injection technique used and an incomplete understanding of the principles of insulin adjustment. Ongoing patient review and education is essential.

Imperfect insulin injections

Case scenario

Jack is new to the practice. He is 68 years old, was diagnosed with type 2 diabetes 18 years ago and started twice-daily premixed insulin three months ago. He has presented because he thinks he is allergic to his insulin: the injection stings, the site swells up and marks develop. Jack pulls up his shirt and shows you his abdomen (Figure 1).

What is causing this problem with Jack's insulin injection?

Jack is injecting his insulin intradermally, which is causing pain, raising a lump and damaging blood vessels, and resulting in bruising and later excess pigmentation. Insulin should be given into the subcutaneous fat where it is absorbed consistently rather than injected superficially into the skin or deeply into the muscle where absorption is more variable. Bruising at the injection site itself affects the rate of insulin absorption and can occur if the insulin pen or syringe and needle move from side to side during the injection, damaging blood vessels. Bruising at injection sites is more common in people taking prescribed antiplatelet or anticoagulant medication and also with use of some over-the-counter and complementary medicines (e.g. NSAIDs, fish oil, gingko products) than in people not taking these medications. Using the correct injection technique (as recommended by the Australian Diabetes Educators Association) ensures that the insulin is given into the subcutaneous fat and that the risk of bruising is minimised (see the Box).[1]

Some diabetes nurse educators recommend different needle lengths for different people on the principle that bigger people need bigger needles. However, although the thickness of the subcutaneous fat layer varies considerably according to age, body site, gender, body mass index and ethnic background, the skin thickness does not vary significantly and therefore people with a larger body mass index do not necessarily need to use a longer needle.[1,2] Also, people usually prefer the shorter (4 to 6 mm) needles (as used in insulin pen injectors) because they cause less discomfort than the longer ones (8 or 12 mm, as used in syringes), and using shorter needles is not associated with any excess problems such as insulin leakage after injection compared with longer needles.[3] Moreover, in most people there is no need to pinch up the skin of the abdomen to inject

Key points

- **Insulin should be injected subcutaneously and the needle/injector should not move after insertion.**
- **Insulin injection technique, including site, should be reviewed as part of the annual cycle of care of a person using insulin.**
- **Premix, self-mix and basal–bolus schedules offer increasing levels of flexibility, effectiveness, complexity and imposition.**
- **A premixed schedule may suit people with a regular daily routine, whereas those with a more variable routine or wanting tighter glycaemic control may prefer a self-mix or basal–bolus schedule.**
- **Differences in endogenous insulin secretion explain why people with type 1 or long-standing type 2 diabetes are more likely to have wide swings in blood glucose levels than those with shorter duration type 2 diabetes.**
- **Any corrective bolus insulin doses should be small, blood glucose levels should be checked two to four hours later and further small bolus doses given if necessary.**

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Figure 1. Jack's abdomen, showing bruising, lumps and pigmentation at insulin injection sites.

insulin into the subcutaneous fat and the injection can be given using one hand. The 'pinch technique' is still recommended in very lean people, even with shorter needles, and for all people using longer needles.

Inappropriate choice of injection area and/or site can cause varied insulin absorption and can be associated with clinically significant glycaemic variability as well as unsightly scars and lumps (hypertrophy).[4] The broad principle to apply when injecting insulin is to consistently use the same general area, preferably the abdomen because it is easy for most people to inject insulin correctly there, and to vary the site of injection. The problems associated with using areas such as the thighs or upper arms and by not varying the site of injection are summarised in Table 1.

Another common problem with insulin injections is pain. Needles are now so sharp and fine that only pressure or the sharpness of the needle is normally felt. If the insertion of the needle is painful, and especially if pain is felt during the injection of the insulin, then something is wrong. A diabetes nurse educator can usually identify the cause of the pain and suggest a solution. The scenarios listed below should be considered.

- Pain as the needle passes through the skin. Wet alcohol on the skin or blunt needles can cause pain – the use of alcohol to cleanse the injection site is no longer considered necessary and long-term reuse of syringes or injector needles is discouraged (needles are available free from the National Diabetes Services Scheme so there should be no need to reuse any needle).
- Pain as the insulin is injected. Cold insulin can cause pain – it is recommended that only the stored insulin be kept refrigerated and that the insulin in use be kept at room temperature (except in extremely hot or cold environments when an insulating box can be used). The long-acting insulin analogue glargine is acidic and can sting, but usually this is a minor problem and patients become used to it.
- Pain from a local reaction. Rarely, the insulin, a protein, can been denatured by heating (e.g. when left in a parked car in summer) or freezing (after excessive refrigeration) and the products cause local reactions. Even more rarely, allergy can occur to one of the components in the insulin preparation.

Part of the annual cycle of diabetes care for people with diabetes who are using insulin should include a review of injection technique and injection sites. It is easy to assume that a person who has been giving

Injecting insulin to the right depth – into the subcutaneous fat

For the most consistent absorption, insulin should be injected subcutaneously rather than intradermally or intramuscularly. Bruising at the injection site itself affects the rate of insulin absorption and can occur if the insulin pen or syringe and needle move from side to side during the injection, damaging blood vessels.

Injecting at a 90° angle is the most common needle injection technique and is appropriate for needle lengths of 4 to 6 mm, as used in pen injector devices. If there is little subcutaneous fat or longer needle lengths are used (syringe needles are 8 mm or more in length) then the pinch technique should be used; alternatively a 45° angle of insertion may be used (use of this angle of insertion should be checked regularly as people often inject at a shallower angle). In the pinch insulin injection technique, inserting the needle at right angles to the skin surface of a fold of skin and subcutaneous fat ensures the insulin is injected into the subcutaneous fat and not the underlying muscle. These techniques are illustrated in Figures A and B.

Side to side movement of the syringe/injector and needle is minimised by holding the syringe/injector between the thumb and third finger with the index finger poised to push the plunger. Alternatively, the syringe/injector may be held in the palm with the fingers folded around it and the thumb poised to push the plunger. If the needle is inserted and then the fingers holding the syringe/injector are rearranged to push the plunger it is easy to move the syringe/injector and cause a bruise.

Figure A. Injecting insulin at a 90° angle (left) and a 45° angle (right).

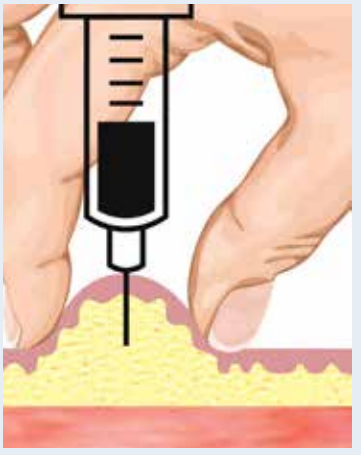

Figure B. Injecting insulin into a skin fold.

themselves injections for months or years knows how to do it but their initial education may have been incorrect and/or they may have taken shortcuts since. Often their initial education is all they receive and errors in self-care are perpetuated or increased.

Premix, self-mix or basal–bolus?

Case continued

Three weeks after a session with a diabetes nurse educator in which his injection technique was reviewed, Jack returns saying he is having problems getting his doses of insulin right. 'I'm using 24 units of 30/70 premixed insulin before breakfast at 06.30 and 12 units before tea. My blood glucose levels are usually high at 12:30 before lunch, but if I increase my morning insulin my blood glucose is low before tea.'

How can Jack even out his blood glucose levels during the day?

Jack is experiencing one of the problems associated with premixed insulins, the inflexibility of the proportions of basal insulin (human isophane; NPH) and bolus insulin (human or analogue). He needs more insulin in the morning (the bolus) but not more of the intermediate insulin affecting the afternoon (the basal).

He could increase the insulin dose and a dietitian could suggest changes to his eating plan so that he has less carbohydrate for breakfast and morning tea and more for lunch and afternoon tea to reduce the blood glucose level in the morning but maintain it in the afternoon. However, this may be inconvenient and might not work.

Alternatively, he could start a more flexible insulin schedule in which he either self-mixes the desired proportions of bolus and basal insulin (a twice-daily self-mix insulin schedule) or separates the basal and bolus components entirely (a basal–bolus schedule). The more complex the schedule, the more flexible and effective it becomes but the larger the imposition of the injection procedure and time required. The various insulin schedules are compared in Table 2.

Premixed and self-mixed insulin schedules use human isophane as the basal component and soluble insulin (human or analogue) as the bolus component. Basal–bolus schedules use both isophane or analogue basal insulin and human or analogue bolus insulin. The analogue preparations have significant advantages over the human insulins: longer duration and more consistent absorption for the basal insulins and higher peak of effect and more rapid onset and offset for the bolus insulins (Table 3).[5] However, these differences may become a problem in some people, as discussed below.

Jack needs the basal insulin component in the morning to control his blood glucose level in the afternoon and the bolus component to control his blood glucose level after breakfast. At present he needs more bolus insulin but not more basal insulin.

If Jack used an analogue bolus insulin, the high peak and rapid onset and offset after the 06.30 injection might mean that his blood glucose level was high before lunch (six hours later at 12.30), when the effect of the morning bolus insulin had worn off. If he used more bolus insulin to overcome this, his blood glucose level is likely to be low mid-morning, at the peak of the bolus effect.

Using a human bolus insulin, with its longer duration and lower peak of action, is more likely to produce the desired effect. In Jack's case, the simplest solution would be for him to start a self-mix schedule using the same doses of basal insulin (70% of his current total daily insulin dose; i.e. 17 units in the morning and 8 units in the evening) and bolus insulin (30% of his current total daily insulin dose; i.e. 7 units in the morning and 4 units at night). He could then titrate the two types of insulin separately to control blood glucose in the morning (the human bolus insulin) and in the afternoon (the basal isophane). The new schedule would also increase the flexibility of his evening insulin dose, allowing him to adjust the bolus component according to the amount and type of carbohydrate he is eating, his blood glucose level before the meal and his level of physical activity in the evening.

Table 1. Insulin injection area and site rotation: possible problems

General area	Injection site*	Possible problems/comments
Rotated – arm, thigh, abdominal wall	Variable	Variable insulin absorption between areas
Fixed – arm, thigh or abdominal wall	Fixed	Injection site scarring and hypertrophy with variable insulin absorption
Fixed – arm or thigh	Variable	Arm – very difficult to inject correctly Thigh – slower absorption and more difficult to inject than the abdomen
Fixed – abdominal wall	Variable	This is the preferred injection strategy

* Site: the spot within the general area where insulin is injected.

Table 2. Characteristics of different insulin schedules

Characteristic	Insulin schedule		
	Basal–bolus*	Twice-daily self-mix†	Twice-daily premix‡
Effective glycaemic control	+++	++	+
Flexible	+++	++	+
Ease of application	+	++	+++
Less time: consuming	+	++	+++

* Basal–bolus: once- or twice-daily (evening and/or morning) dose of basal insulin plus mealtime dose(s) of bolus insulin.
† Twice-daily self-mix: twice-daily doses of basal (isophane) and bolus insulins mixed in syringe or given as two injections with a pen injector in fixed or variable proportions.
‡ Premix: twice-daily mealtime injections of premixed insulin in fixed proportions of bolus and basal insulins.

Table 3. Pros and cons of analogue insulins compared with human insulins

Pros of analogue insulin	Cons of analogue insulin
Basal	
• Consistent profile • Often single daily dose • Less hypoglycaemia than with isophane insulin • No mixing or resuspension needed for injection	• Slower response to dose changes than with isophane insulin • May be confused with bolus insulins as both are clear solutions • Cannot be mixed with bolus insulins • Glargine may sting when injected
Bolus	
• Inject when eating • Less hypoglycaemia than with human insulin • Better postprandial glycaemic control than with human insulin	• Need to eat promptly after injection • Possible insulin 'run out' before next meal • Need adequate carbohydrate in meal

A diabetes nurse educator should show him the correct technique to draw up the insulins and advise him on dosage adjustment. A dietitian could advise him on the basics of carbohydrate counting.

HI – going up or coming down?

Case continued

Jack is back again. 'Yesterday when I woke my blood glucose reading was 15.6. I took 10 units of bolus insulin and by lunchtime the reading was HI. This morning it was 16 so I took a bit more bolus insulin, 15 units, and had a crashing hypo at morning tea time. How can I get it right?'

How should insulin be used to correct hyperglycaemia?

Jack's problem was that he knew his blood glucose level was high but he did not know whether it was on the way up or down. On day 1, it was probably on the way up and the 10 units of insulin did not correct it. On day 2, it was on the way down and he had his crashing hypoglycaemic episode. When using extra boluses of insulin to correct hyperglycaemia it is wise to use a small dose (e.g. 5 to 10% of the total daily insulin dose), checking the blood glucose level two to four hours later and repeating the dose if necessary, rather than giving a large initial dose (e.g. 20% of the total daily insulin dose) that would fix a rising blood glucose level but cause a hypoglycaemic episode if the blood glucose level were falling.

Problems with wide glycaemic swings are much more common in people with type 1 diabetes and those with long-standing type 2 diabetes (such as Jack) who have no or little endogenous secretion of insulin to compensate for increased or decreased insulin requirements due to extra exercise, stress or food. Too much or too little insulin can cause wide swings in blood glucose levels, with many adverse effects.

Most people in general practice care using insulin have type 2 diabetes, and this proportion is increasing as it is recognised that up to 50% of people with type 2 diabetes require insulin within five to 10 years of diagnosis.[6-8] Managing insulin in people with type 2 diabetes is usually relatively easy because there is some residual insulin secretion to give a buffer.

Summary

Problems can arise in people with type 2 diabetes treated with insulin because of less than ideal techniques of injection being used and an incomplete understanding of the principles of insulin adjustment.

Reviewing insulin injection technique is part of the annual cycle of diabetes care in general practice. Use of the recommended technique makes insulin injection simpler, less painful and less likely to cause problems at the injection site.

Compared with a premix insulin schedule, basal–bolus or self-mixed insulin schedules are more flexible and effective but more complex and time-consuming. Premixed schedules may suit people with a regular daily routine and basal–bolus or self-mixed schedules may suit those with a variable routine or if tighter glycaemic control is desired.

People with type 1 or longstanding type 2 diabetes are more likely to have wide glycaemic swings than those with shorter-duration type 2 diabetes, who have a buffer of ongoing endogenous insulin secretion. Any corrective bolus insulin doses should be small (5 to 10% of the total daily insulin dose), blood glucose levels should be checked a few hours later and further small bolus doses given if necessary. **ET**

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