National Patient Safety Agency

Rapid Response Report NPSA/2010/RRR013:
Safer administration of insulin

June 2010

Supporting Information

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1. Introduction

Insulin is a naturally-secreted hormone which the body needs for correct function and plays a key role in the regulation of protein, fat and carbohydrate metabolism. It facilitates glucose circulating in blood to be absorbed by cells. Injecting insulin is an essential part of the daily regimen for many diabetics. In the UK, diabetes affects approximately 2.3 million people.

Deaths and severe harm incidents have resulted from administration errors with insulin products. In general, using insulin is safe. However, there is a potential for serious harm if it is not administered and handled properly.

Insulin is frequently included in the list of top10 high-alert medicines worldwide and the scope of this Rapid Response Report (RRR) covers all indications for insulin therapy including hyperkalaemia and glucose intolerance.[1-4] A high-alert medicine is defined as a medicine that has the highest risk of causing patient injury when misused.

Common causes of errors with insulin are inaccurate dosing and administration, leading to too much circulating glucose (hyperglycaemia) or too little circulating glucose (hypoglycaemia). Commonly higher than required doses of insulin are administered in error, which result in hypoglycaemia. This can happen suddenly and if left untreated, can cause confusion, clumsiness, or fainting. Severe hypoglycaemia can lead to seizures, coma, and death.

2. Background

Insulin syringes

Administration errors have resulted from the use of intravenous syringes to measure and administer doses of insulin. The use of intravenous syringes to measure insulin doses in units is an error prone practice as the graduations are in volume, not units of activity. Administration errors have also resulted when healthcare practitioners have not had sufficient training or work competencies to ensure the safe administration of insulin.

Current UK licensed insulin products are manufactured to have 100 units per ml where units are a standardised measure of activity. The one millilitre (1 ml) 100 units per ml insulin syringe is commonly graduated in major 10 unit markings and minor 2 unit markings.

Insulin syringes referred to in this guidance are therefore unlike standard syringes as their markings are based on units, not volume, and have a capacity of 1 ml or less.

If a standard syringe is used to measure a dose prescribed as units there may be confusion over the graduation mark to obtain the intended dose, resulting in a dosing error.

For this reason it is important that insulin syringes are used to draw up and administer insulin doses in the UK. The cost of insulin syringes is less than 1 ml IV syringes with a needle.

Insulin pens

Insulin pens contain cartridges pre-filled with insulin. These pens meter the required dose but training is required to ensure the devices are used safely. Mis-operation of insulin pens may result in omitted or delayed doses or an incorrect dose being administered.

Professional competence to administer doses of insulin

Health professionals must recognise the limits of their personal knowledge, skills and competence regarding the administration of insulin therapy. If they are required to prepare and administer insulin, for example using an insulin pen device which they are unsure how to operate, they should seek additional help and support.

Abbreviations

Use of abbreviations such as 'U' for 'units' has led to 10-times dose administration errors. This is because when the letter 'U' is written next to the intended insulin dose it may be read with an extra '0' and an overdose administered in error. For this reason the British National Formulary specifies that the word 'unit' should not be abbreviated.[5]

Examples of errors with other abbreviations have been reported, such as 'IU' which may also be confused for '10' or '0'. Abbreviations, possibly common in other EU countries, may also be used by non-UK trained staff or those with overseas experience, such as 'U', Θ, or 'Ū'.

The proximity of the word 'unit' with a dose, as in '10units' has also been associated with 10 times overdose as it is read as '100nits'. This will be accentuated when a capital is used for units as in '10Units'. While the use of the word 'unit' rather than 'U' is a logical solution it must be recognised that lower case should be used and a space left between the dose and the word. In this example it would best be seen as "10 units". Use of this semantic should reduce error from misperception with the word 'unit' itself.

The use of the full word 'unit' is also advised for on-screen display by Information Technology (IT) prescribing and dispensing systems of insulin products.[6]

Use of 500 unit insulin

Some patients may be insulin resistant and require relatively large doses. Higher strength insulin products of 500 units per ml are available as licensed products in the USA. A small number of 500 units per ml insulin products are imported into the UK as unlicensed medicines on a named patient basis each month.

Unfortunately 500 units per ml syringes are not available in the USA or the UK. The Veterans Health Administration in the USA have reported confusion between the two strengths of insulin products during prescribing, dispensing and administration, leading to significant patient harm.[7] The Institute for Safe Medicines Practices in the USA have recommended that doses of 500 unit per ml insulin products should be prescribed on a named patient basis only, in both units and mls (millilitres) and that the dose should not be administered using a 100 unit per ml syringe but rather by using a 0.5ml or 1ml intravenous syringe. Experience from America suggests this is the least error prone method for administration.[8]

In the UK NHS Diabetes have recommended that 500 units per ml insulin products must be kept completely separate from all other insulins, be clearly labelled and only be administered by staff who have had specific training in its use.[9]

Industry has commenced on the development of a 500 units per ml syringe and the NPSA is working with medicine regulators and manufacturers to support the introduction of these syringes to support the safe administration of the higher strength insulin products.

Pre-filled syringes

For patients who suffer repeated or unpredictable hypoglycaemia despite optimal multi-injection regimens[10] or a marked morning rise in blood glucose, insulin infusions are indicated. Insulin infusions are also routinely used in the hospital sector for treatment of acute conditions.

In order to minimise risks arising from the calculation, measurement and dilution of insulin, consideration should be given to the supply and use of prefilled syringes of ready to administer fast acting insulin 50 units in 50ml sodium chloride 0.9%. Acute sector pharmacy departments may manufacture prefilled syringes. Alternatively commercially available pre-filled ready to administer syringes of 50 units in 50 ml are available. The acquisition costs of commercially prepared prefilled syringes are more than the separate costs of insulin, sodium chloride and consumables (for example syringes) used to prepare insulin infusions in clinical areas although manpower costs of the clinical staff used to prepare these infusions have not been included.

Omitted and delayed doses of Insulin

An NPSA review of reported medication incidents from 2007 revealed that omitted and delayed medicines was the second largest cause of medication incidents reported to the National Reporting and Learning System (NRLS). The data highlighted that for some kinds of medicines, such as antibiotics, anticoagulants and insulin, an omitted or delayed dose can have serious and even fatal consequences. Local medicine management procedures should include guidance on the timeliness of insulin administration. Guidance on reducing harms associated with omitted and delayed doses of medicines in the hospital sector can be found at: www.nrls.npsa.nhs.uk/resources/?EntryId45=66720

3. Review of evidence of harm

Between August 2003 and August 2009 the NPSA received 3,881 wrong dose incidents involving insulin. These included one death and one severe harm incident due to 10 times errors from use of abbreviation of the term ‘unit’.

Three deaths and 17 other incidents between January 2005 and July 2009 were also reported where an intravenous syringe was used to measure and administer insulin.

3.1 Errors arising from the use of intravenous syringes for insulin

a) Incidents in acute hospitals

The NPSA is aware of two deaths that have occurred in the acute setting that directly relate to the use of an IV syringe used to prepare and administer insulin. In both cases junior medical staff were unaware that 1 ml of insulin measured in an IV syringe did not correlate to a 1 unit dose, or that insulin syringes should be used when administering insulin.

Incidents reported to the NPSA describe healthcare professionals using a non insulin syringe for the preparation or administration of insulin. Examples are as follows (taken verbatim from the NRLS database):

“Patient given 0.8 mls of Novomix 30 insulin instead of 8 units. Nurse thought 1 ml syringes were the same as insulin syringes.”

“Doctor prescribed 6 units Actrapid. Drew up 0.6mls of Actrapid in a non insulin syringe - thinking this was 6 units. Realised it was not a syringe in units and Actrapid is 100 units / ml. 60 units had been given.”

“Comments by student midwife that midwife may have inadvertently given 0.8mls of insulin in a 1ml syringe with an orange needle. 8 units were prescribed. Woman had severe hypo requiring dextrose and a sliding scale insulin.”

Other identified risks related to the inadvertent overdose of insulin when administered as an infusion. Measuring and preparing insulin to add to diluents for infusion involves an additional step in an already error prone process. For example:

“When setting up GKI infusion used wrong syringe and added incorrect amount of insulin - 1.2 mls instead of 12 units.”

“Staff member was preparing an infusion for a syringe driver - the correct requirement was 0.5mls of insulin made up with 49.5mls of normal saline. The error was 5mls of insulin was drawn up and added to 49.5mls of saline.”

b) Incidents in community sector

The NPSA was informed of a fatal incident that involved a healthcare professional who, unfamiliar with the patient’s usual insulin pen device and without sufficient supplies of insulin syringes, used a non-insulin syringe to prepare and administer the insulin dose.

“Due to the patient's poor eyesight, a nurse administered the daily insulin glargine. On the day of the incident, the nurse who came to administer the insulin glargine had not seen the patient or the Opticlik before and had not received any training on the use of the Opticlik. When the nurse attempted to use the Opticlik device the pen jammed. The next Opticlik pen she tried also jammed. The nurse then drew up the insulin glargine from within the Opticlik cartridge system with a needle and syringe. The syringe was not an insulin syringe, and the nurse misread what she was supposed to administer. The patient was supposed to receive 36 units. The nurse injected three times, until the cartridge became empty, and then withdrew an additional 60 units from a second cartridge and injected this. The patient received a total of 360 units of insulin. Two to three hours later the patient was falling asleep in the car with a friend. The patient became hot, flushed, and did not feel well. She required assistance getting out of the car, and fell to the floor. The paramedics were called, and the patient died. It was reported that the patient had hypoglycaemia episode and her heart had stopped.”

Healthcare professionals in the community setting are expected to be proficient with a multitude of insulin delivery devices which may impose an additional risk unless there is a readily available source of training for staff to ensure competency.

“Phone call from patient’s husband to say patient BM test result was 16 and needed to give Novorapid which was sent home with patient when discharged the day before. The hospital had not sent any needles and syringes so husband asked if the healthcare assistant could bring some. The healthcare assistant collected what she thought were insulin syringes and some brown needles and took them to house. The wrong syringe was used and the patient was given overdose of 800 units (8mls) instead of 8 units into his abdomen.”

3.2 Errors arising from abbreviation of insulin 'units'

"Patient fitted and had hypoglycaemic event, became aggressive and confused. Blood glucose 3.1. Patient had been given 44u Insulatard in the morning instead of 4u as prescribed . ."

"A patient on the GP unit was prescribed 10units of Glargin insulin. At midday two qualified nurses checked the medication chart and both read it as 100 units this dose was then administered. The patient became ill and was transferred to the acute trust where her blood sugar level was recorded as 0.5. Hypostop was administered and blood sugar levels recorded at 8.4 and then 12. Patient died in A / E department at 0400hrs. Doctor recorded that death was Left Ventricular Failure and not secondary to the overdose. Pathologist and Coroner informed by the acute trust."

"I read the syringe wrong and gave 80 units of insulin instead of 8 units. I did not realise at first as was distracted by the patient waving a knife around which she had been cutting strawberries with. I did think this is a larger amount than usual in the syringe but was then distracted I then went to another patient but I went back and checked the syringe after and realised what I had done."

"Incorrect dose of insulin administered to patient, prescription stated 6 units 60 units given."

References

1) Institute of Safe Medication Practice (USA). *List of High Alert Medicines*. 2008. Available at http://www.ismp.org/Tools/highalertmedications.pdf

2) National Patient Safety Agency. *Patient Safety Observatory Report 4*. *Safety in Doses*. 2007. Available at http://www.nrls.npsa.nhs.uk/resources/patient-safety-topics/medication-safety/?entryid45=59822&q=0%c2%acsafety+in+doses%c2%ac

3) National Patient Safety Agency. *Safety in Doses*. 2009. http://www.nrls.npsa.nhs.uk/resources/patient-safety-topics/medication-safety/?entryid45=61625&q=0%c2%acsafety+in+doses%c2%ac

4) Santell JP, Cousins DD, Hicks R. Top 10 drug products involved in medication errors. Dr Topics 2003;147;HSE23-4

5) Joint Formulary Committee. *British National Formulary*. 58 ed. London: British Medical Association and Royal Pharmaceutical Society of Great Britain; 2009:374

6) NPSA. *Design for Patient Safety: Guidelines for safe on-screen display of medication information*, 2010:30. http://www.nrls.npsa.nhs.uk/resources/collections/design-for-patient-safety/?entryid45=66713 (accessed 25/2/2010)

7) Veterans Health Administration. Patient Safety Alert. Medication Safety- Insulin U-500 Safety Enhancements. March 2009

8) Institute for Safe Medication Practices. Medication Safety Alert. Extra caution with U-500 Insulin. January 1997

9) Fowler D, Rayman G, Safe and effective use of insulin in hospitalised patients. NHS Diabetes 2010:recommendation 18,8

10) NICE. Continuous subcutaneous insulin infusion for the treatment of diabetes mellitus. Review of technology appraisal guidance 57 2008 (http://www.nice.org.uk/nicemedia/pdf/TA151Guidance.pdf accessed 25/2/2010)

Appendices

Appendix 1: Rationale for actions

Number	Action	Rationale
1	All regular and single insulin (bolus) doses are measured and administered using an insulin syringe or commercial insulin pen device. Intravenous syringes must never be used for insulin administration.	The use of IV syringes calibrated in mls for insulin presented in 100 units per ml is an error-prone method that has caused fatal patient safety incidents. Definitive guidance is required to indicate that only insulin syringes or commercial insulin pen devices should be used for all regular and one-off doses.
2	The term 'units' is used in all contexts. Abbreviations, such as 'U' or 'IU', are never used.	There is sufficient evidence of patient safety incidents and harm arising from ten times dosing errors when abbreviated forms of unit are misread. Eliminating the use of abbreviations will help to minimise dose communication errors.
3	All clinical areas and community staff treating patients with insulin have adequate supplies of insulin syringes and subcutaneous needles, which staff can obtain at all times.	In order to ensure compliance with recommendation 1 and to provide a safe backup method for the administration of insulin where an insulin pen device cannot be used for whatever reasons, stocks of insulin syringes and subcutaneous needles are required in all clinical areas and for community staff. Arrangements should be in place for additional supplies of these devices to be available at all times.
4	An insulin syringe must always be used to measure and prepare insulin for an intravenous infusion. Insulin infusions are administered in 50ml intravenous syringes or larger infusion bags. Consideration should be given to the supply and use of ready to administer infusion products e.g. prefilled syringes of fast acting insulin 50 units in 50ml sodium chloride 0.9%.	Insulin infusions may be prepared in a syringe or infusion bag or container. Insulin infusions are prepared in clinical areas, hospital pharmacy departments or commercially by dilution of insulin injections with sodium chloride 0.9% or another infusion fluid. Measurement of insulin injections before dilution should be conducted using an insulin syringe to minimise the risk of dose confusion and manipulation error. The use of a standard strength (50 units in 50ml sodium chloride 0.9%) prefilled syringes of fast acting insulin in clinical areas reduces the risk of preparation error.
5	A training programme should be put in place for all healthcare staff (including medical staff) expected to prescribe, prepare and administer insulin. An e-learning programme is available	Staff should be informed of the dangers inherent in prescribing, preparing and administering insulin products and safe practice procedures designed to minimise these risks. They should receive training to achieve the necessary knowledge-based and practical competencies to prescribe, prepare, administer and monitor insulin safely.

	from NHS Diabetes: www.diabetes.nhs.uk/safe_use_of_insulin	
6	Policies and procedures for the preparation and administration of insulin and insulin infusions in clinical areas are reviewed to ensure compliance with the above.	Policies and procedures in local organisations should describe safe practice required to be used to ensure patient safety. Local organisations should also have systems to audit the implementation of policies and procedures and identify incidents arising from non-compliance, and take actions to ensure safe practice is occurring.

Appendix 2: Compliance checklist

The recommendations in this RRR relate to all healthcare sectors and specialties where the preparation and administration of insulin occurs.

Primary care trusts and local health boards have responsibilities to ensure that the contents of the RRR are communicated to relevant independent contractors, who should be aware of the risks and take the necessary actions.

Number	Recommendation	Suggested evidence to indicate compliance	Y/N
1	All regular and single insulin (bolus) doses are measured and administered using an insulin syringe or commercial insulin pen device. Intravenous syringes must never be used for insulin administration.	Ensure that local policies and procedures include a statement requiring the use of an insulin syringe or commercial insulin pen and warning of the risks of using intravenous syringes to measure and administer insulin doses. Include the above information on specialist insulin charts. Record that the above has been reviewed and approved by an organisational committee. Also record the communication strategy to promote safer practice.	
2	The term 'units' is used in all contexts. Abbreviations, such as 'U' or 'IU', are never used.	Ensure that local policies and procedures include a statement requiring the use of 'units' in full and warning of the risks of using abbreviations. Include the above information on specialist insulin charts. Longer term, plan to redesign charts so that 'units' is at the top of column and prescribers record the number of units required and do not need to write 'units' alongside these figures. Record that the above has been reviewed and approved by an organisational committee. Also record the communication strategy used to promote safer practice.	
3	All clinical areas and community staff treating patients with insulin have adequate supplies of insulin syringes and subcutaneous needles, which staff can obtain at all times	Record that agreed stock holdings and procedures for obtaining insulin syringes has been reviewed and approved by an organisational committee. Record the communication strategy to promote safer practice.	
4	An insulin syringe must always be used to measure and prepare insulin for an intravenous infusion. Insulin infusions are administered in 50ml intravenous syringes or larger infusion bags. Consideration should be given to the supply and use of ready to	Local policies and procedures should include a statement requiring the use of an insulin syringe to measure and prepare insulin for an intravenous infusion. Record that an organisational committee has reviewed and approved the above and the internal communication strategy to promote safer practice.	

	administer infusion products e.g. prefilled syringes of fast acting insulin 50 units in 50ml sodium chloride 0.9%.	Record that a review of the use of prefilled insulin syringes has taken place and the decision on whether these syringes will be introduced into practice.	
5	A training programme should be put in place for all healthcare staff (including medical staff) expected to prescribe, prepare and administer insulin. An e-learning programme is available from NHS Diabetes: www.diabetes.nhs.uk/safe_use_of_insulin	Put in place an ongoing multidisciplinary training programme for the safe use of insulin. Make full use of the NHS Diabetes e-learning training programme. Include a system to enable review of course completion and follow-up. Details of the number of staff who have completed/not completed the training programme should be reported to an organisational committee at least once a year. Record that the above has been reviewed and approved by an organisational committee. Also record the communication strategy.	
6	Policies and procedures for the preparation and administration of insulin and insulin infusions in clinical areas are reviewed to ensure compliance with the above.	Put in place an ongoing multidisciplinary training programme for the safe use of insulin. Make full use of the NHS Diabetes e-learning training programme. Include a system to enable review of course completion and follow-up. Details of the number of staff who have completed/not completed the training programme should be reported to an organisational committee at least once a year. Record that the above has been reviewed and approved by an organisational committee. Also record the communication strategy.	