

# Pharmacists' role in ensuring safe and effective hospital use of insulin

MICHAEL R. COHEN

**M**edications that are associated with the highest risk of injury when used in error are known as high-alert medications.<sup>1</sup> Insulin is consistently among those identified as a high-alert medication.<sup>2,3</sup> One characteristic of high-alert medications (including insulin, parenteral chemotherapy, opiates, i.v. potassium chloride, and others) is their low therapeutic index. Although insulin therapy can be lifesaving in the hospital setting, it can be life threatening if used inappropriately.<sup>4</sup> Insulin errors may be twice as likely to result in harm to patients as errors involving other medications. The United States Pharmacopeia described 4764 insulin errors over a two-year period that were reported to the MEDMARX voluntary reporting program (now operated by Quantros).<sup>5</sup> Approximately 6.6% of these caused harm to the patient. One of the 12 interventions that the Institute for Healthcare Improvement recommends for its 5 Million Lives Campaign is "Prevent Harm from High-Alert Medications," starting with a focus on anticoagulants, sedatives, narcotics, and insulin.<sup>6</sup> The campaign's goal is to achieve a 50% re-

**Purpose.** To highlight the potential errors that may occur with insulin use in the inpatient setting and to describe how pharmacists can be part of the solution by implementing practices that reduce the likelihood of insulin-related medication errors.

**Summary.** Insulin is a drug with a low therapeutic index, and it bears a heightened risk of causing significant patient harm when used in error, making it a high-alert medication. Both underdosing and overdosing of insulin may be associated with adverse outcomes. The use of standard insulin order sets for scheduled subcutaneous insulin administration and standard concentrations for i.v. insulin are recommended to ensure the safe use of this medication. Any ambiguous insulin therapy orders should be clarified in writing prior to administration. Preparation of all insulin infusions should occur within the pharmacy. Pharmacists should be aware of possible medication errors related to inappropriate use of abbreviations such as *U* for *units*. Safe insulin storage practices are recommended to reduce the risk for insulin

error. Insulin pen delivery devices may be used in hospitals, but safe use depends on ongoing oversight by a multidisciplinary committee, introduction of one device at a time, and initial and regular follow-up education of nurses, including agency nurses and those who work part-time. In addition, ongoing monitoring is needed to assure ongoing safety. The use of sliding-scale insulin can lead to hyperglycemia and hypoglycemia and is confusing and prone to error; it is not recommended.

**Conclusion.** Pharmacists can contribute to the safe use of insulin in the inpatient setting by minimizing the likelihood of medication errors related to prescribing, transcription, dispensing, administration, storage, and communication.

**Index terms:** Abbreviations; Dosage; Drug administration; Errors, medication; Hospitals; Insulin; Insulins; Pharmaceutical services; Pharmacists, hospital; Prescribing; Protocols; Storage; Toxicity

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duction in harm related to high-alert medications.<sup>6</sup> This article will discuss ways in which clinical pharmacists can support the safe and effective use of insulin in the hospital setting.

## Types of medication errors associated with insulin therapy

Omission errors (leading to hyperglycemia) and improper dose or quantity (leading to hyperglycemia

MICHAEL R. COHEN, B.S.PHARM., M.S., SC.D., is President, Institute for Safe Medication Practices, 200 Lakeside Drive, Suite 200, Horsham, PA 19044 (mcohen@ismmp.org).

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or hypoglycemia) are the two most frequently reported types of error associated with insulin usage.<sup>5</sup> Untreated hyperglycemia in patients with known diabetes mellitus and those without documented diabetes is associated with poor outcomes.<sup>7</sup> Underdosing or missed doses of insulin in diabetic patients can lead to poor outcomes, such as ketoacidosis. Insulin-induced hypoglycemia may result in a range of symptoms from nausea to falls and to the risk of myocardial ischemia.<sup>8</sup>

Types of insulin-use errors include prescription and transcription errors such as illegible orders, missing or misplaced zeros and decimal points, use of unsafe abbreviations, and ordering of an unintended formulation. Dispensing errors may arise from look-alike or sound-alike

medications or incorrect preparation of injectable doses. Errors associated with administration include incorrect dosage, drug, or infusion rates and lack of drug monitoring or double-checking.<sup>9</sup> Medication given to the wrong patient is also classified as an administration error.<sup>9</sup>

The use of unsafe medical abbreviations to order insulin increases the risk for serious errors. The Joint Commission National Patient Safety Goal 2B states that each hospital should standardize a list of abbreviations, symbols, acronyms, and dose designations that are not to be used within the organization.<sup>10</sup> For example, the abbreviation *U* for *unit* is on the official “do not use” list created by the Joint Commission.<sup>11</sup> When insulin is ordered, the word *units* should be written out; *mL/hr* should be used

rather than *cc/hr* for insulin infusions because *cc* can be mistaken for *U*. Table 1 identifies some medical abbreviations that can cause confusion with regard to insulin prescribing.<sup>12</sup>

**Recommended safety practices**

Pharmacists can establish and enforce safe ordering guidelines. Standardized order forms that list specific products and contain prompts to specify administration times in relation to meals are recommended, as are the use of standardized insulin infusion protocols.<sup>13</sup> The use of standardized order forms for insulin has been shown to decrease medication errors and episodes of hypoglycemia, the most dangerous effect of insulin.<sup>14-16</sup> Pharmacists can prohibit acceptance of orders containing trailing zeros and *U* in place

Table 1. Medical Abbreviations to Avoid<sup>a</sup>

Abbreviation	Intended Meaning	Misinterpretation	Correction
BT	Bedtime	b.i.d. (twice daily)	Use <i>bedtime</i>
cc	Cubic centimeters	U (units)	Use <i>mL</i>
D/C	Discharge or discontinue	Medications discontinued prematurely when term is intended to mean “discharge”	Use <i>discharge</i> or <i>discontinue</i> as intended
IJ	Injection	i.v. or i.j. (intrajugular)	Use <i>injection</i>
HS	At bedtime	Half-strength	Use <i>at bedtime</i>
IU <sup>b</sup>	International unit	i.v. or 10	Use <i>units</i>
q.d. or QD <sup>b</sup>	Daily	q.i.d (four times daily)	Use <i>daily</i>
Qhs	Nightly at bedtime	q hr (every hour)	Use <i>nightly</i>
qn	Nightly or at bedtime	q h (every hour)	Use <i>nightly</i> or <i>at bedtime</i>
q6PM etc.	Every evening at 6 p.m. daily	Every 6 hours	Use <i>daily at 6 p.m.</i>
Sub q	Subcutaneous	q understood as meaning “every” (e.g., “sub q 2 hours before surgery” interpreted as “every 2 hours before surgery”)	Use <i>subcut</i> or <i>subcutaneously</i>
U or u	Unit	0, 4, or cc (e.g., 4U interpreted as 40, 44, or 4 cc)	Use <i>unit</i>
Trailing zero after decimal point (e.g., 1.0 mg) <sup>b</sup>	1 mg	10 mg	Do not use trailing zeros for doses
No leading zero before a decimal point (e.g., .5 mg) <sup>b</sup>	0.5 mg	5 mg	Use zero before a decimal point when the dose is less than a whole unit

<sup>a</sup>Adapted from reference 12.

<sup>b</sup>The Joint Commission has established a National Patient Safety Goal that specifies that these abbreviations must appear on an accredited organization’s “do not use” list.

of *units*. Handwritten insulin therapy orders or handwritten components of preprinted order sets should be legible and clearly written. All illegible orders should be clarified in writing prior to administration. Any ambiguous insulin therapy orders should be clarified in writing prior to administration. Oral and telephone orders for insulin should be minimized and used only when necessary in urgent medical situations. The receiver of the order should write down the complete order or enter it into a computer, then the receiver should read it back (rather than only repeating it back before writing it) and receive confirmation from the individual who gave the order.<sup>9</sup> This helps ensure that the order was both properly heard and properly transcribed.

Preparation of all insulin infusions within the pharmacy is recommended. Pharmacists should verify the diagnosis and indication for insulin to assure orders have not been accidentally processed for a non-diabetic patient.<sup>17</sup> A standard insulin concentration to prepare infusion bags should be employed.<sup>5</sup> Pharmacists should prepare and dispense prefilled syringes for once-daily doses of long-acting insulin but only when they can be given within the labeled time frame. Staff can be alerted to insulin-containing i.v. solutions and differentiate them from other infusions by use of a brightly labeled bag. Finally, all insulin preparations should be independently double-checked against original orders prior to dispensing.

Pharmacy-prepared vials of low-concentration neonatal insulin should be labeled with bold warnings (e.g., “NICU only”). An empty sterile vial, different in size from standard insulin vials, should be used to dispense insulin; this helps to further distinguish the diluted neonatal insulin. Be sure any preparation instructions clearly state which insulin dilution should be used. Employ a

checklist and documentation log to ensure proper verification by at least one pharmacist who was not involved in the actual admixture of both the volume and concentration of insulin added to the solution.

Be cautious of ambiguous manufacturer labeling and packaging. This has largely been rectified by the use of color differentiation of insulin products by manufacturers. However there have been mix-ups between similar names of insulin products (e.g., Humalog and Humulin R, Novolog and Novolin, Novolog 70/30 and Novolin 70/30). Applying “tall man” (mixed case) lettering to dissimilar portions of name can be helpful (e.g., HumALOG versus HumULIN, NovoLOG versus NovoLIN). Use other means to “make things look different” or call attention to important information (e.g., stickers, labels, enhancement with pen or yellow marker).<sup>18</sup>

### Insulin delivery devices

Use of the correct insulin syringe is extremely important. The Institute for Safe Medication Practices (ISMP) and the Pennsylvania Patient Safety Reporting System have received several reports describing errors in which a nurse administering insulin selected a tuberculin rather than an insulin syringe and gave a 10-fold overdose (e.g., 0.9 mL [90 units] for a 9-unit dose).<sup>19</sup>

Several institutions have transitioned from vials to patient-specific insulin pen devices as a way to reduce the risk of errors. However, errors associated with pen injectors can occur in the health care setting. Cautions against using insulin pens like vials (by aspirating contents out of the pen cartridge with a needle) and using the same pen for multiple patients have been published previously.<sup>20</sup> On the basis of reports from ISMP, FDA has released an alert reminding health care professionals that single-patient insulin pens and insulin cartridges must not be

used for multiple patients, even if the needles are changed between patients, due to the risk of transmitting bloodborne pathogens such as hepatitis and human immunodeficiency virus.<sup>21</sup> Insulin pen delivery devices may be used in hospitals, but safe use depends on oversight by a multidisciplinary committee, introduction of one device at a time, and initial and regular follow-up education of nurses, including agency nurses and those who work part-time. In addition, ongoing monitoring is needed to assure ongoing safety. This would require constant monitoring via a risk-management function.

The presence of a window on the pen device allows direct visualization of the number of units being administered, which has the potential to reduce dosing errors. Nurses who learn to appropriately use the pens are able to educate patients on using them at home. The insulin volume in pens is less than that in vials and may yield cost advantages for patients with short hospital stays or low insulin requirements.<sup>22</sup> Eli Lilly provides a 3-mL vial of regular insulin human, which may also reduce costs in these situations.

Sometimes nurses incorrectly use insulin pen devices as vials because they like the technique required to use the pen less than that for the traditional needle and syringe. However, use of pen as a vial can damage the integrity of the pen as a result of altering the pressure dynamics, with consequent introduction of air into the cartridge. Large pockets of air have been observed in cartridges of insulin pen injectors after aspirating some of the drug with a needle. If the pen injector or cartridge is not discarded and the air is not eliminated before delivering a subsequent dose, the patient could receive less than the desired dose of insulin as well as a subcutaneous injection of air. The use of pens as vials may also lead to unlabeled sy-

rings of insulin on the nursing unit, which is not acceptable.<sup>23</sup>

There is potential for inadvertent needle sticks of nursing personnel secondary to not maintaining the 90-degree angle of the pen device to the skin pinch.<sup>24</sup> Misalignment of this angle results in the needle traveling through the skin pinch into the finger of the nurse, resulting in a dirty needle stick. Use of a single pen device on multiple patients results in an infection-control risk because of contamination of the pen device. Pens are for single-patient use only.

The wide variety of pen injector designs makes it difficult for health care practitioners, particularly nurses, to learn how to use them properly and maintain competence. Suggestions for safe introduction of insulin pen devices include oversight by a multidisciplinary committee, introduction of one device at a time and initial and follow-up nurse education. A requirement for initial and periodic testing of proficiency and competency may also be considered.<sup>22</sup> A recently published study shows that implementation of insulin pen devices does not increase nursing time spent to teach patients to self-inject insulin and does not increase insulin-related needlestick injuries.<sup>25</sup>

Furthermore, compared with patients treated with conventional insulin vials and syringes during hospitalization, increased patient satisfaction and continuation at home of the method of insulin administration used in the hospital have been reported by patients treated with insulin pens.<sup>26</sup> This is an important consideration in improving long-term glycemic control of the many patients with diabetes who are discharged from hospitals.<sup>26</sup>

### U-500 insulin

Clinicians should be aware that patients who require U-500 insulin and use a U-100 syringe may report

their doses incorrectly. For example, a reported dose of 50 units (read on the U-100 scale) may actually be a dose of 250 units. U-500 strength should be avoided for insulin doses less than 100 units.<sup>27</sup> Some errors seem to be related to the position of information about insulin product listings on computer screens. Depending on the screen size, the entire insulin product description, particularly the drug concentration if it is listed last, may not be visible. Since U-500 insulin is not common, prescribers may not look for information about concentration if they believe insulin is available only in a U-100 concentration. ISMP has contacted the major drug-information vendors that provide inventory information for electronic systems, and they have agreed to reorder this information or use the word *concentrate* for U-500 following the drug name.

### Sliding-scale insulin

The use of sliding-scale insulin has been in question for years.<sup>28</sup> Sliding-scale insulin is often used in hospitals, but its use has not been substantiated by clinical evidence. It is a reactive rather than proactive approach to managing the blood glucose concentration (BG). Discontinuation of this practice is recommended.<sup>29</sup> However, if sliding-scale insulin is ordered, precautions should be put into place. Sliding-scale insulin should only be ordered on a preprinted order or computerized order set created and approved by the organization.<sup>30</sup> Long-acting insulin should not be used in a sliding-scale, and scheduled insulin should be ordered in place of sliding-scale insulin.<sup>31</sup>

One hospital reported to ISMP that physicians typically prescribe a sliding scale of insulin as “2 units Humulin R for each BG 50 > 150.” The intended interpretation is to administer 2 units of Humulin R insulin for a BG of 151–200 mg/dL, 4 units for a BG of 201–250 mg/dL, 6 units for a BG of 251–300 mg/dL, and so on.

When this hospital’s pharmacists began providing work coverage at another affiliated hospital, they learned that this order was being interpreted differently. In that hospital, the staff thought that “BG 50 > 150” implied that the scale should begin at 200 mg/dL. Thus, patients were receiving 2 units of Humulin R insulin for a BG of 200–250 mg/dL, 4 units for a BG of 251–300 mg/dL, 6 units for a BG of 301–350 mg/dL, and so on.

### Insulin storage practices

Safe insulin storage practices have been recommended to reduce the risk for insulin error.<sup>30</sup> Unusual vial concentrations (e.g., U-500) should be removed from patient care areas. Insulin and heparin should be separated on nursing units and in the pharmacy (because one drug has been given when the other was prescribed<sup>32</sup>), while insulin syringes should be stored apart from tuberculin syringes. An insulin vial should be labeled with the patient’s name and vial expiration time per institutional guidelines. Consider conducting unit inspections to ensure proper labeling and disposal of insulin per institutional guidelines. Do not dispense insulin in its original carton. Instead, discard the carton upon dispensing because nurses sometimes accidentally place insulin vials of one type in a carton meant for another. Pharmacists and nurse managers should provide ongoing education and oversight to ensure that insulin pens are not shared among patients and that cartridges are not used to prepare insulin doses with a conventional insulin syringe.

### “Hold” orders

Pharmacists can improve safety by maintaining awareness of enteral feedings and alerting staff when diabetic patients with insulin orders have their feedings held or discontinued. Elevated BG values from enteral feedings are often treated with an intermediate- or a long-

acting subcutaneous insulin. When enteral feedings are stopped or held for diabetic patients, any insulin they are receiving needs adjustment or discontinuation. Directions to adjust or discontinue insulin under these conditions should be listed prominently on medication administration records and with any documentation about enteral feedings. An example of what should not happen is as follows. A diabetic patient receiving continuous enteral feedings was also receiving subcutaneous isophane insulin 24 units twice daily to control elevated BG values.<sup>33</sup> The feedings were then held for a computed tomography scan, but no one discontinued the insulin. By the time the BG was checked again, it measured only 26 mg/dL.

## Conclusion

Pharmacists can contribute to the safe use of insulin in the inpatient setting by minimizing the likelihood of medication errors related to prescribing, transcription, dispensing, administration, storage, and communication.

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