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ISMP

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Educating the Healthcare Community About Safe Medication Practices

Medication errors during insulin administration for patients with hyperkalemia

Hyperkalemia (an elevated blood potassium level exceeding normal range) is a serious, potentially lethal electrolyte disturbance that requires immediate medical treatment if it is severe enough to cause disturbances in cardiac conduction. Although hyperkalemia treatment guidelines in the literature vary,[1] many organizations begin treatment with the administration of one or more intravenous (IV) bolus doses of 50% dextrose and an IV bolus dose of 10 units of either a rapid-acting insulin (i.e., insulin aspart, insulin lispro) or a short-acting insulin (i.e., regular insulin).

Errors when treating hyperkalemia

When treating hyperkalemia, the potential for errors and patient harm is significant due to the urgency of the treatment, the difficulty in measuring and administering bolus doses of IV insulin, and the risk of treatment-induced hypoglycemia. A 2017 analysis of almost 200 adverse events associated with hyperkalemia treatment showed that delayed treatment and administration of insulin by the wrong route or the wrong dose (mostly overdoses) were the most common types of errors.[1] The analysis also showed that, despite the administration of dextrose, hypoglycemia was still a relatively common occurrence often linked to the variability in dextrose and insulin dosing, the type of insulin used, duration of the dextrose and insulin infusion, the sequence of administering the dextrose and insulin, and patient factors such as renal dysfunction. Some episodes of hypoglycemia have also been caused by administering only the insulin portion of the treatment and not the glucose component.[2]

Causes of errors

Delays. Most delays have occurred because treatment was postponed until patients were transferred to another unit, or there were no immediate signs of changes on a patient's electrocardiogram (EKG). Although the effects of hyperkalemia can be detected on an EKG as peaked T waves, a prolonged PR-interval, and a widened QRS-interval,[1] an EKG is a poor indicator of hyperkalemia severity. Patients with hyperkalemia who meet criteria for treatment based on their potassium level should be treated without delay even in the absence of EKG changes, because even benign changes can quickly progress to lethal arrhythmias.[3]

Wrong route. Some insulin wrong route errors have occurred during order entry when IV insulin was mistakenly prescribed by the subcutaneous route. This error was sometimes caused by an automatic default to the subcutaneous route for routine insulin prescribed outside of standard order sets that had been developed for IV insulin. In these cases, the prescriber did not use the hyperkalemia order set to prescribe the insulin, or no such order set existed. In other cases, the IV insulin was mistakenly administered subcutaneously, perhaps because it was a more familiar route of administration. Insulin should be given IV when treating hyperkalemia to promote consistent bioavailability.[1,4]

Dosing errors. Most dosing errors have involved measuring insulin doses in mL

continued on page 2—Hyperkalemia >

ISMP now accepting Fellowship applications

ISMP is now accepting applications through **March 31, 2018**, for two unique 2018-2019 yearlong Fellowship programs commencing mid- to late-summer 2018. The ***ISMP Safe Medication Management Fellowship*** offers a nurse, pharmacist, or physician an unparalleled opportunity to learn from and work with some of the nation's experts in medication safety. The ***FDA/ISMP Safe Medication Management Fellowship*** offers a healthcare professional an opportunity to work with medication safety experts at ISMP for 6 months and the US Food and Drug Administration (FDA) Division of Medication Error Prevention and Analysis for 6 months. All candidates must have at least 1 year of postgraduate clinical experience and relocate to the area. For details, visit: www.ismp.org/sc?id=3064.

SAFETY wires

Caution advised with tamper-evident caps. The design of tamper-evident caps can pose a choking hazard to susceptible patients. Many hospitals use the red plastic tamper-evident caps available from suppliers for oral and parenteral syringes containing controlled substances. These products are useful in reducing the risk of tampering and diversion because, once the seal on the cap is broken, it is immediately apparent that the integrity of the syringe and its contents may have been compromised. It is important for practitioners to be aware, however, that these commercially available caps are designed in a way that can leave a small plastic "ring" on the syringe. On larger syringes, the retained ring sits near the syringe tip. With 1 mL syringes, the smaller diameter

continued on page 2—SAFETY wires >

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> Hyperkalemia—continued from page 1

instead of units (e.g., 10 mL instead of 10 units), misreading the measurement markings on syringes, and not understanding the differences between insulin syringes and other parenteral syringes. Some dosing errors have occurred because practitioners failed to recognize that the U-100 strength of insulin equates to 100 units in each mL, and because they were either practicing outside of their scope of practice or had never been educated about the administration of insulin IV.[2,3] Providing the required insulin in vials rather than the exact dose, particularly without directions for measuring the dose, has also contributed to errors. In a 2011 analysis, we found that human error (e.g., mental slips, lapses, forgetfulness) associated with insulin dose measurement and hyperkalemia treatment was a predominant cause of dosing errors.[2]

However, at the crux of many of these errors is the lack of a luer-compatible insulin syringe without a needle that can be used to measure and administer IV insulin via needleless access devices and lines. Most insulin syringes in hospitals have an attached needle appropriate for subcutaneous administration of medications. Additionally, some hospitals are only using insulin pens, which are likewise an inappropriate device to measure and administer IV insulin doses via a needleless system. This has resulted in several unsafe practices, including: 1) distribution of hyperkalemia treatment kits that, instead of insulin syringes without a needle, contain a tuberculin syringe and vial of rapid- or short-acting insulin; 2) calculating the volume of insulin needed for each dose so a luer-compatible (non-insulin) syringe can be used for administration, which has resulted in calculation and measurement errors; and 3) measuring doses in an insulin syringe, and then transferring the dose to a parenteral syringe for IV administration, which can potentially lead to dose inaccuracies and infection control breaches.

Examples of recent errors

Several recent insulin errors during hyperkalemia treatment were reported to ISMP or have appeared in the literature. For example, just last month, we learned about an error in which a nurse correctly calculated the volume needed for a 10 unit dose of insulin lispro, but accidentally measured out 20 units of insulin using a 10 mL non-insulin syringe. A physician prescribed treatment that included calcium gluconate 1 g IV, insulin lispro 10 units IV, and dextrose 50% IV. The nurse calculated that she would need 0.1 mL of the insulin for the 10 unit dose, and a nurse manager verified the calculation. Using a 10 mL syringe, she drew the insulin lispro into the syringe up to the first gradation mark, believing this represented 0.1 mL. But the first syringe marking was actually 0.2 mL. The nurse manager did not verify the dose in the syringe prior to administration. The error was quickly discovered when a clinical nurse specialist asked the nurse, who had just completed orientation, to demonstrate how she had measured the insulin dose in a 10 mL syringe. The patient's blood glucose was monitored, and she experienced no adverse effects.

Another event appeared in recent literature involving a medical resident working in interventional radiology (IR) who gave the wrong dose of insulin to a hemodialysis patient with hyperkalemia.[3] The hospitalized patient was scheduled for replacement of her dialysis access in IR. On the day of the procedure, her potassium level was 5.9 mmol/L (normal adult range in this laboratory was approximately 3.5 to 5.1 mmol/L), and she was treated with **KAYEXALATE** (sodium polystyrene sulfonate). A repeat potassium level was drawn, and the result, 6.9 mmol/L, was reported to IR during the procedure. Because the patient was stable without EKG abnormalities, treatment was delayed until after the procedure.

When the procedure had been completed, a resident went to the pharmacy to request the medications needed for hyperkalemia treatment, including 10 units of regular insulin. The pharmacy dispensed a 3 mL vial of U-100 regular insulin

continued on page 3—Hyperkalemia >

> SAFETY wires continued from page 1

barrel may cause the ring to slide down over the barrel area. These rings can pose a choking hazard if they fall off the syringe and into a patient's mouth during drug administration.

The manufacturer recommends discarding the ring before administering the drug to the patient. However, this information is in printed material that doesn't accompany the syringe and may not be seen by those administering the medication. The ring for the oral syringe cap is red (**Figure 1**). The ring for the parenteral syringe cap is clear, making it less noticeable. If the ring is left in place, it may slide into a patient's mouth during administration. An alert adult or child may swallow or spit out the ring, but a neonate, infant, or young child, or even an adult with a decreased gag or cough reflex or altered mental status, may aspirate the ring. The risk for children could be increased if the ring is close in size to the larynx and gets stuck. If the ring enters the lung, it can increase the risk of pneumonia. The actual risk appears to be low, and we have not received reports of harm. However, we are aware of an incident in which several rings were found in the mouth of an obtunded patient receiving oral liquid opioids.



Figure 1. When removed, the tamper-evident cap for the oral syringe leaves a ring (arrow) on the syringe, which poses a choking hazard if not removed prior to administration.

An ENFit version of the tamper-evident cap is available in blue, but it does not have a ring that can be retained on the syringe after removal. Also, there are other types of tamper-evident seals on the market that are taped over the syringe tip. However, we occasionally receive complaints about these seals falling off even before the medication is to be administered.

continued on page 3—SAFETY wires >

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> Hyperkalemia—continued from page 2

without clarification that only 0.1 mL would be needed for a 10 unit dose. The resident mistakenly administered the entire vial of insulin (300 units) instead of 10 units. He had little prior experience measuring and preparing insulin doses since medication administration of this type was not within his scope of practice.

When the dosing error was identified, a rapid response team was called. The patient was treated with a 10% dextrose infusion along with 4 bolus doses of 50% dextrose in the first 30 minutes, and then dialysis. The patient was transferred to an intensive care unit (ICU) and able to tolerate meals with carbohydrates to provide a more physiological delivery of glucose. Glucose and potassium levels stabilized, and the patient was transferred out of the ICU within 2 days.

Recommendations

Treatment protocols. Establish standard hyperkalemia protocols that specify the threshold for treatment based on severity (e.g., potassium level above which to act), the corresponding pharmacological and clinical interventions, and monitoring parameters to gauge the patient's response to the treatment. Ensure adequate monitoring of glucose levels and signs and symptoms of hypoglycemia during treatment, even if dextrose is being administered, and for several hours after insulin administration. Hypoglycemia may occur up to 6 hours after dextrose and insulin administration, especially if the patient has renal dysfunction.[1,5]

In the protocols, also specify: 1) the insulin type, dose, and route of administration; 2) how to flush the IV line or access site, if necessary, to ensure the small volume of insulin has been fully administered; 3) the concomitant dextrose concentration, volume, and route of administration; and 4) the specific doses and administration information for all other pharmacological interventions (e.g., sodium bicarbonate, calcium chloride/gluconate, furosemide).

Standard order sets. Create standard order sets for hyperkalemia treatment and require their use. Treatment should only be prescribed using a standard order set that is automatically populated with the correct dose and route of administration for the required medications, including insulin. If the insulin dose is to be administered IV push via a syringe, include on the order set a reminder to use a luer-compatible insulin syringe without a needle, and to flush the line or access site if necessary to ensure the small volume of insulin has been fully administered. These reminders should also appear on the medication administration record.

Treat at threshold. Do not delay treatment of hyperkalemia based on the absence of symptoms or EKG changes once an established severity threshold for treatment has been reached. If patient transfer to another unit is necessary, accomplish the handoff as soon as possible so treatment can begin.

Pharmacy preparation or kits. Have pharmacy prepare, label, and dispense IV insulin doses in a ready-to-use form, either in a luer-compatible insulin syringe that can connect to a needleless system, or diluted in a small minibag. Although hyperkalemia is a medical emergency, the administration of insulin, in most circumstances, can wait until a pharmacist prepares a stat dose. If 24-hour pharmacy service is not available, stock hyperkalemia treatment kits on patient care units in automated dispensing cabinets (ADCs). The kits should contain 50% dextrose injection along with a 3 mL vial of rapid- or short-acting insulin (to lessen the potential amount of insulin a patient could receive in error), a luer-compatible needleless insulin syringe, a removable needle or transfer device to withdraw the insulin from the vial to the syringe, a label for the syringe (to apply after preparation but before administration), a vial or syringe of a compatible flush solution, alcohol swabs, as well as directions for preparing and administering the dose (including the concen-

continued on page 4—Hyperkalemia >

> SAFETY wires continued from page 2

If you are using the red plastic tamper-evident caps, please make sure to follow through with the manufacturer's instructions to remove the ring before administration. Nurses who use this product are likely aware of the retained rings. However, they should be reminded of the potential choking hazard and to remove and dispose of the ring prior to drug administration. Further, any delivery device with "component parts" should be carefully inspected prior to placing it in or near a patient's mouth. As with all types of syringe caps, never leave any plastic cap at the bedside, as some patients may confuse it with an oral medication, or children may put it in their mouth. ISMP has contacted the manufacturer, International Medical Industries, regarding the discovery of rings in a patient's mouth.

Vaccine error potential with new herpes zoster vaccine for shingles. Last October, the US Food and Drug Administration (FDA) approved a new herpes zoster vaccine, **SHINGRIX** (zoster vaccine recombinant, adjuvanted), which is referred to as RZV by the Centers for Disease Control and Prevention (CDC). For more than a decade, the medical community has been vaccinating patients with **ZOSTAVAX** (zoster vaccine live, or ZVL), the only herpes zoster vaccine on the market before now. But Shingrix and Zostavax have different storage requirements, components/diluents, and routes of administration. GlaxoSmithKline, the manufacturer of Shingrix, has received a small number of error reports involving these differences between the two vaccines.

The Shingrix vaccine includes two components, a vial containing the lyophilized powder antigen component, and a vial containing the adjuvant suspension component, which must be mixed together prior to administration. Both vials must be stored under refrigeration. The Zostavax vaccine, manufactured by Merck Sharp & Dome, also includes two components, a vial containing the lyophilized powder vaccine, and a vial of sterile diluent supplied by the manufacturer in a separate package. While both components of Shingrix must be stored under refrigeration, the vaccine component of

continued on page 4—SAFETY wires >

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> Hyperkalemia—continued from page 3

tration and volume per dose). Other medications needed for hyperkalemia treatment can typically be obtained from a code cart or ADC but may be provided in the kit if necessary.

Luer-compatible insulin syringes. Carefully evaluate whether luer-compatible needleless insulin syringes are needed in certain patient care units (e.g., critical care, emergency department). BD and Monoject offer these syringes; for an example, see: www.ismp.org/sc?id=3095. Due to the risk of inadvertent use for subcutaneous insulin doses that could then be accidentally administered IV, limiting use of these syringes for pharmacy-dispensed insulin doses or in hyperkalemia kits is preferred. If the syringes are made available in certain units, separate their storage from other insulin and parenteral syringes (e.g., stock only in code carts, away from other syringes) so they are less likely to be inadvertently mixed up. Ensure the syringes are not automatically removed from stock due to low use.

Double check. Require an independent double check of all IV insulin doses to confirm the patient and the insulin type, concentration, dose, amount in the syringe, route of administration, and indication prior to administration (calculated dose and amount in the syringe).

Education. Provide education to all practitioners and students who might prescribe, dispense, and administer medications used to treat hyperkalemia, including IV insulin. Don't assume that all practitioners are knowledgeable and skilled with measuring doses and administering IV insulin. Cover the types and concentration of insulin used during treatment, recognition of safe dosage ranges, the availability of luer-compatible needleless insulin syringes, the differences between insulin syringes and other parenteral syringes, how to measure insulin doses, and how to administer IV insulin. Clearly define the scope of practice for practitioners that allows or disallows IV insulin administration, and restrict insulin preparation and/or administration to those who have demonstrated competency.

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New FREE ISMP CE opportunities

ISMP has two new on-demand programs that address subcutaneous insulin use in adults and sterile compounding safety. These programs offer a convenient way for nurses, pharmacists, and pharmacy technicians to earn medication safety CE credit at no cost. To access them online, go to: http://proce.learnercommunity.com/products/1780 and http://proce.learnercommunity.com/products/1779.

> SAFETY wires continued from page 3

Zostavax must be frozen and the diluent can be refrigerated or stored at room temperature. If either component of Shingrix is improperly frozen, it must be discarded.

Also, the product components are not interchangeable—for example, the diluent provided with Zostavax cannot be used to prepare the lyophilized Shingrix, and the adjuvant suspension component with Shingrix cannot be used to prepare the lyophilized Zostavax. The lyophilized Zostavax should only be mixed with the Merck-supplied diluent, and the lyophilized Shingrix should only be mixed with the adjuvant suspension provided by the manufacturer. The Shingrix components should be stored with one another (in a carton or rubber banded together) to reduce the risk of using a diluent from another vaccine. Finally, Shingrix must be administered intramuscularly, while Zostavax is given subcutaneously. Please pass on this information to providers who manage vaccine programs or administer vaccines at your practice site.



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