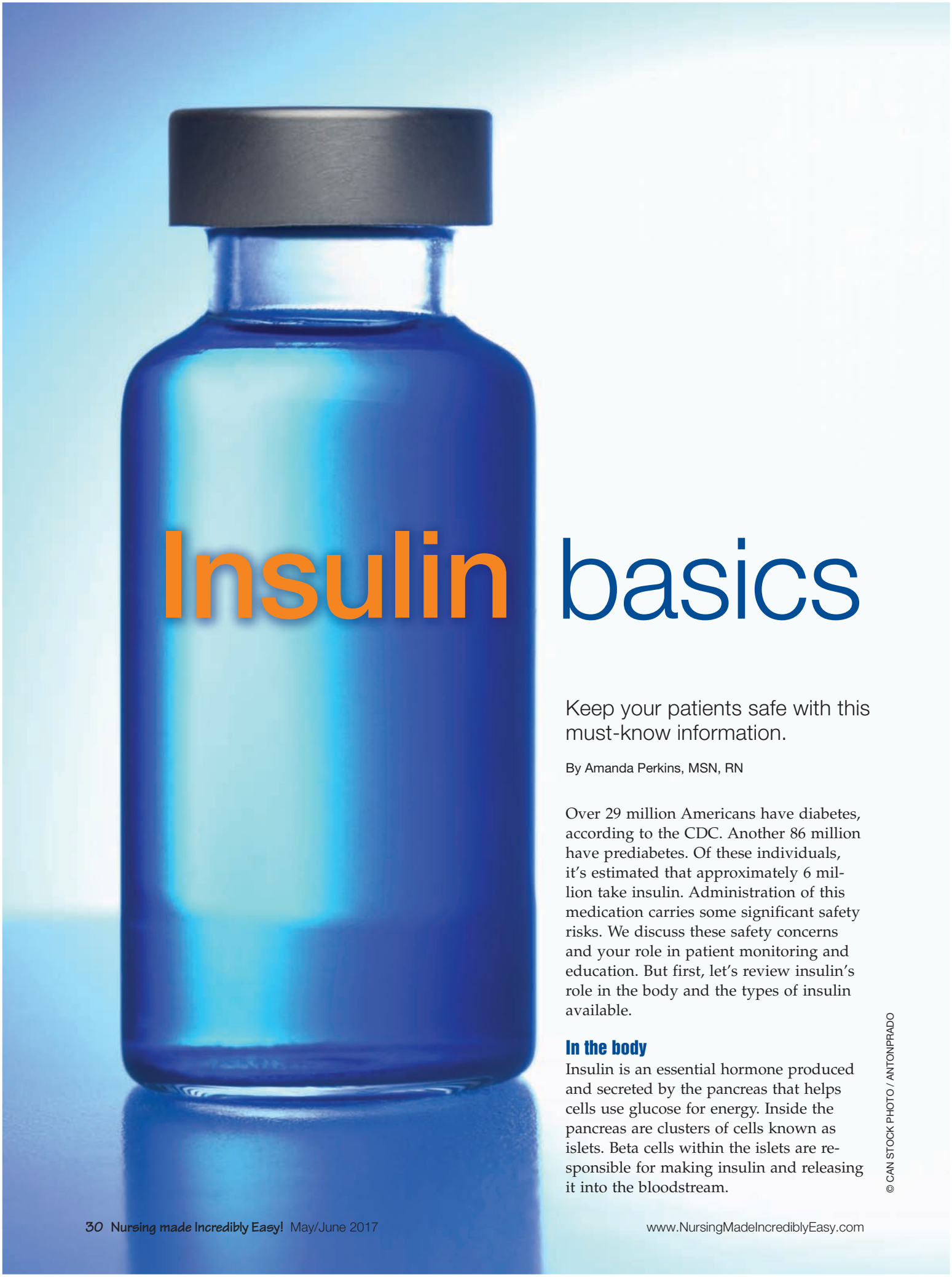

Insulin basics

Keep your patients safe with this must-know information.

By Amanda Perkins, MSN, RN

Over 29 million Americans have diabetes, according to the CDC. Another 86 million have prediabetes. Of these individuals, it's estimated that approximately 6 million take insulin. Administration of this medication carries some significant safety risks. We discuss these safety concerns and your role in patient monitoring and education. But first, let's review insulin's role in the body and the types of insulin available.

In the body

Insulin is an essential hormone produced and secreted by the pancreas that helps cells use glucose for energy. Inside the pancreas are clusters of cells known as islets. Beta cells within the islets are responsible for making insulin and releasing it into the bloodstream.

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When a person eats carbohydrates, the body breaks them down into the simple sugar glucose, which is then used as the body's main energy source. As circulating glucose levels in the bloodstream rise, the pancreas releases insulin, which helps the glucose enter the cells. When insulin is released into the bloodstream, it comes into contact with the cell membrane and combines with a receptor that allows glucose transporters to be activated. Think of insulin as the key that opens up the cell so that glucose can enter.

With type 1 diabetes mellitus, the body doesn't make insulin because the beta cells within the pancreas have been destroyed. These individuals require insulin administration for the rest of their lives. With type 2 diabetes mellitus, insulin is made in the pancreas, but the body doesn't respond well to it. These individuals may require an oral medication, insulin, or a combination of both. Be aware that insulin can't be taken orally because it's broken down during digestion and becomes ineffective.

Insulin requirements may change for each patient depending on a variety of circumstances, such as stress or illness. When caring for a patient with a diagnosis of diabetes, you may need to contact the healthcare provider regarding insulin administration requirements while the patient is stressed or ill.

Acting lesson

Insulin was first isolated and purified in the 1920s; there are as many as 20 different types of insulin used in the United States today (see *History of insulin*). The differences between the types of insulin are related to how they're manufactured, what they do in the body, and how much they cost.

Insulin is prescribed for patients based on onset, peak, and duration. Onset is the length of time that it takes for the insulin to reach the bloodstream and start lowering the blood glucose level. Peak is the time at which the insulin is at maximal strength, causing the blood glucose level to be at its lowest point. Duration is the length of time that it takes for the insulin to be used up by the body.

Insulin comes in a variety of different forms, such as rapid-acting, short-acting, intermediate-acting, and long-acting.

- Rapid-acting insulin starts working in approximately 15 minutes (onset), is most effective at approximately 1 hour (peak), and stays active in the body for 2 to 4 hours (duration). Types of rapid-acting insulin include insulin glulisine, insulin lispro, and insulin aspart.

History of insulin

1920s: Researchers at the University of Toronto carry out a clinical trial with insulin obtained from cattle pancreases

1921: Insulin is discovered by researchers at the University of Toronto

1922: Leonard Thompson is the first patient treated with insulin

1923: Researchers at the University of Toronto apply for a U.S. patent and later sell it to the university for $1

1930s: Hans Christian Hagedorn and his colleagues discover a way to prolong the action of insulin

1946: Neutral protamine Hagedorn (NPH) is patented

1950s: Slow-acting insulins are first introduced

1970s: Innovations improve the purity of insulin and reduce its associated adverse reactions

1978: Scientists use recombinant DNA technology for insulin production

1982: Regular and NPH insulins are available in the United States as the first marketable products created through recombinant DNA technology

1996: Insulin lispro is the first short-acting insulin analogue available in the United States

2000: The short-acting insulin aspart is approved for use in the United States

2005: The short-acting insulin detemir is approved for use in the United States

2015: The first inhaled insulin is approved for use in the United States

Sources: Greene JA, Riggs KR. Why is there no generic insulin? Historical origins of a modern problem. *N Engl J Med*. 2015;372(12):1171-1175.

Kelto A. Why is insulin so expensive in the U.S.? www.npr.org/sections/health-shots/2015/03/19/393856788/why-is-u-s-insulin-so-expensive.

National Museum of American History. Humulin N, NPH, human insulin (recombinant DNA origin) isophane suspension. http://americanhistory.si.edu/collections/search/object/nmah_1000967.

• Short-acting insulin starts working in approximately 30 minutes (onset), is most effective at approximately 2 to 3 hours (peak), and stays active in the body for 3 to 6 hours (duration). Types of short-acting insulin include insulin regular.
• Intermediate-acting insulin starts working in approximately 2 to 4 hours (onset), is most effective at approximately 4 to 12 hours (peak), and stays active in the body for 12 to 18 hours (duration). Types of intermediate-acting insulin include insulin NPH.
• Long-acting insulin starts working several hours after injection (onset) and continues to work over a 24-hour period of time (duration). Types of long-acting insulin include insulin detemir and insulin glargine.

Mix it up

When caring for patients who require insulin, it may be necessary for you to mix it. In nursing school, many of us learned "clear to cloudy." Although this is an easy way to remember how to mix insulin, it's important to understand the principles behind it to decrease errors and make insulin administration safer.

Keep in mind that rapid- or short-acting insulin is clear and intermediate-acting insulin is cloudy. The rapid- or short-acting insulin (clear) is drawn up first to prevent the intermediate-acting insulin (cloudy) from getting into the rapid- or short-acting insulin bottle and affecting the onset, peak, and duration. The intermediate-acting insulin (cloudy) won't be altered in the way that the rapid- or short-acting insulin will be if a minute amount of mixing occurs. For a detailed description of how to mix insulin, see *Mixing insulin.*

Administration smarts

Insulin is most commonly administered with a syringe, but can be given via insulin pens and pumps. Additionally, fast-acting insulin can be administered I.M. or I.V. in urgent situations.

With insulin pens, a dial on the pen is used to choose the correct amount of insulin to be administered. A needle is used with the insulin pen.

Insulin pumps are beneficial because they do a good job of mimicking how the body normally releases insulin. An insulin pump delivers insulin 24-hours a day through a catheter/needle inserted into the subcutaneous tissue. Once the catheter is in place, it only needs to be changed every

Mixing insulin

1. Start with the intermediate-acting insulin (cloudy) and roll it between your hands to mix.
2. Clean the top of the intermediate-acting and rapid/short-acting insulin (clear) bottles with alcohol.
3. Remove the syringe cap and pull the plunger back to the correct number of units of intermediate-acting (cloudy) insulin.
4. Insert the needle into the intermediate-acting insulin (cloudy) and inject air into the bottle.
5. Remove the needle and pull the plunger back to the correct number of units of rapid/short-acting (clear) insulin.
6. Insert the needle into the rapid/short-acting (clear) insulin and inject air into the bottle.
7. Invert the bottle with the needle still in place and pull the plunger back until the ordered amount of rapid/short-acting insulin (clear) is in the syringe. Make sure to remove all air bubbles because this can't be done after this point.
8. Remove the needle/syringe and insert it into the inverted intermediate-acting insulin (cloudy) bottle.
9. Carefully pull the plunger back and draw out the ordered amount of intermediate-acting insulin (cloudy). ***Note:*** Use caution during this step because you can't push excess insulin back into the bottle. If you draw out too much insulin, you need to discard the syringe and start over from step 1.
10. Remove the needle/syringe. You're ready to administer your insulin mixture.

Source: Cleveland Clinic. Instructions for insulin injection using two bottles of insulin. my.clevelandclinic.org/health/articles/instructions-for-insulin-injection-using-two-bottles-of-insulin.

2 to 3 days, significantly decreasing the amount of needle sticks that the patient must receive. Insulin pumps deliver a continuous dose of medication, known as a basal dose; a bolus dose can be administered at mealtimes. Blood glucose levels still need to be monitored while using the pump.

When administering insulin, it's important to choose the appropriate site because some sites work faster than others. The abdomen is the fastest route. In order to prevent tissue injury, insulin injection sites should be rotated. Due to the fact that insulin is absorbed at different rates depending on the administration site, it's recommended that the same area (such as the abdomen) be used for a week at a time. Sites within the area should also be rotated. For example, choose different areas of the abdomen, ensuring that each injection is spaced at least 1 inch from the previous one.

Error alert

Medication errors involving insulin can cause significant harm and, in some cases, death. Some of the more commonly reported insulin administration errors are omission of insulin, delayed insulin, incorrect insulin product (rapid-acting versus long-acting), and incorrect dose. Omitted or delayed insulin may lead to hyperglycemia, which can have potentially serious complications. Incorrect insulin product and incorrect dose can lead to either hyperglycemia or hypoglycemia. Research has shown that, in many instances, insulin is administered too early, leading to hypoglycemia.

In the healthcare setting, errors may occur as the result of similar names or packaging for different types of insulin and confusing or nonuniform sliding-scale insulin orders. For example, insulin is dissolved or suspended in liquids and typically comes as 100 units per milliliter (U-100). However, it can also come in a strength of 500 units per milliliter (U-500). This type is available for patients who are resistant to insulin. Always check the strength of insulin before administering it; mistaking U-500 for U-100 can be deadly.

Administering insulin I.V. also carries potential risks. Many healthcare facilities use "soft stops" and "hard stops" for insulin infusion pumps to prevent administration errors. Typically, the pharmacy programs soft and hard stops into the pumps. A soft stop forces the nurse administering the medication to take extra steps if the insulin dose is outside of an agreed on range. The pump will still allow the insulin to be administered, but the nurse using the pump must read and accept an alert that it's outside the recommended range. A hard stop is a safety feature that doesn't allow a certain dose of insulin to be administered. The pump will alarm, causing the nurse to stop and contact the healthcare provider for further orders.

To prevent errors when administering insulin, ensure that you're giving the correct dose, at the correct time, to the correct patient. Also monitor patients for adverse reactions after insulin administration and closely monitor the blood glucose levels of patients who are pregnant or stressed because insulin requirements may increase in these instances.

In addition, follow these safety tips:

- double check the insulin order before administering
- clarify unclear orders

Signs and symptoms

cheat sheet

Hypoglycemia

- Hunger
- Sweating
- Pallor
- Tremors
- Palpitations
- Headache
- Confusion
- Syncope
- Seizures
- Coma

Hyperglycemia

- Polydipsia (excessive thirst)
- Polyuria (excessive urination)
- Polyphagia (excessive hunger)
- Nocturia (nighttime urination)
- Fatigue
- Blurred vision
- Abdominal pain
- Headache
- Vomiting
- Fruity breath odor
- Rapid, deep breathing

• don't accept orders with the abbreviation "u" in place of units
• never interchange insulins without consulting the healthcare provider
• know the onset, peak, and duration for all insulin products that you're administering
• use only insulin syringes when drawing up insulin.

Understanding onset, peak, and duration will ensure that you're knowledgeable about when your patient should eat, when you should monitor blood glucose levels, and when you should monitor for hypo- or hyperglycemia. Although you need to follow orders pertaining to blood glucose monitoring, it's acceptable and expected that you'll check blood glucose levels based on your nursing judgment; for example, if a patient is displaying signs and symptoms of hypoglycemia.

Patient focus

In addition to maintaining your own knowledge base, it's important to provide patient education and follow-up regarding insulin. Patient teaching should include the following:
• what insulin is and why it's ordered
• proper technique of drawing up and administering insulin
• what equipment should be used
• how to store insulin
• where to discard syringes
• the importance of never sharing insulin syringes or insulin pens
• how and when to check blood glucose levels
• insulin requirement changes that occur when pregnant, stressed, or ill
• nutrition and exercise requirements
• signs and symptoms of hypo- and hyperglycemia, and when to call the healthcare provider.

Education regarding insulin should be ongoing, as should evaluation of patient understanding. These patients need continual support because insulin administration outside of the hospital setting will be long-term.

Innovation station

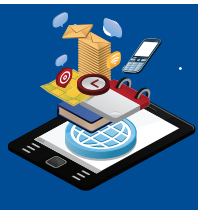
As technology advances, changes and improvements to insulin are occurring. Current innovations include inhaled insulin and new insulin formulations.

Insulin human inhalation powder is a rapid-acting inhaled insulin product that became available in the United States in 2015. Administered at the beginning of each meal, the powder enters the body through the lungs, where it's moved within 5 to 6 seconds to the bloodstream. Suitable for patients with type 1 and type 2 diabetes, it's used in conjunction with injectable long-acting insulin. Before starting inhaled insulin, patients should have their lung function tested. Patients who smoke or have chronic lung disease shouldn't be given inhaled insulin. This medication hasn't been tested in children.

New insulins include a concentrated, slow release insulin glargine, which requires less injections, and the slowly and consistently released basal insulin degludec, which allows for more flexible dosing.

Current research is underway to develop an insulin that lasts 3 to 4 days, significantly reducing injections and decreasing the risk of complications. It's estimated that this medication is years away from being available to consumers. Another interesting form of insulin that's being researched is "smart" insulin that's controlled based on circulating blood glucose levels. This type of insulin is active when needed (high blood glucose level) and inactive when not needed (normal or low blood

on the web



American Association of Diabetes Educators: www.diabeteseducator.org

American Diabetes Association: www.diabetes.org

CDC: www.cdc.gov/diabetes/home/

Cleveland Clinic: http://my.clevelandclinic.org/health/articles/diabetes-basics

Diabetes Research Institute Foundation: www.diabetesresearch.org

Insulin for Life USA: ifl-usa.org

National Institute of Diabetes and Digestive and Kidney Diseases: www.niddk.nih.gov

glucose level). It's estimated that this insulin may be ready for clinical trials within the next 5 years.

The evidence is in

As nurses, it's our responsibility to ensure competence, including being appropriately educated regarding insulin and utilizing evidence-based practice when administering insulin and caring for patients receiving it. In addition to maintaining our own competence, we must also ensure that our patients are properly educated regarding insulin. Staying up to date will help improve patient outcomes. ■

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did you know?

Insulin should be kept in the refrigerator for long-term storage, but can be kept at room temperature for 1 month. It's more comfortable for patients to receive room-temperature insulin.

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INSTRUCTIONS

Insulin basics

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