
Diabetes and Acute Metabolic Emergencies

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Introduction

Diabetes mellitus (DM) is a metabolic disorder in which there is insufficient insulin production, or the body is unable to utilize the insulin which is being produced. In the United States there are 20.8 million children and adults with diabetes mellitus, another 54 million people suffer from a condition known as pre-diabetes, and 135,000 pregnant women every year develop gestational diabetes.^{1,2} The “diabetic emergency” call is already commonplace within the EMS system, and prehospital personnel diagnose and treat diabetic emergencies on a regular basis. With 650,000 new cases of diabetes being diagnosed in the U.S. each year, the potential patient pool is constantly on the rise.³

History

The term “diabetes” was first coined by the Greeks when Arateus described it as “the melting down of flesh and limbs into urine”.^{4,5} It was depicted as weight loss which occurred in young, lean people and was accompanied by an increase in thirst, hunger and urination (polydipsia, polyphagia, and polyuria respectively).⁵ The term “mellitus” is a Latin word for honey and

stems from the abnormal amounts of glucose found in the urine of diabetics. It was added later by “water tasters” who would diagnose diabetes by drinking the patient’s urine searching for a sweet-taste.⁴

In 1979 the National Diabetes Data Group (NDDP) published diagnostic criteria and classifications for diabetes mellitus which included the terms juvenile and adult onset. In 1997 the American Diabetes Association recommended revising and simplifying these classifications resulting in the terminology (Type 1 and Type 2) commonly used today.^{5,6}

Anatomy and physiology

The pancreas is an elongated, retroperitoneal organ which lies horizontally along the posterior abdominal wall between the duodenum and the spleen. The head of the pancreas is located in the right upper abdominal quadrant attached to the duodenum by two ducts, and the other end (the tail) lies on the left side. This gland possesses both endocrine and exocrine properties; the exocrine portion secretes digestive enzymes into the small intestine via the ducts. The endocrine portion consists of many

small groups of cells called the islets of Langerhans, or pancreatic islets, and each group of islets contain alpha, beta and delta cells.

Glucose is the major source of energy for the body, and it wants to constantly maintain a blood glucose level (BGL) ranging from 70 to 110 mg/dl.⁷ When BGL falls, the alpha cells secrete the hormone glucagon which stimulates the liver to convert its stored glycogen into glucose, a process known as glycogenolysis. Glucagon also promotes the release of glucose from other storage sites.

Insulin is an antagonist to glucagon. During hyperglycemic states, for example after eating a meal, the pancreatic beta cells release the hormone insulin that stimulates the storage of glucose and its conversion to glycogen in the liver. Insulin also binds to its cellular receptor sites, acting as the key that allows glucose to enter the cell and be used for energy. The brain is the only organ which doesn't require insulin to utilize glucose.

The role of delta cells is to produce somatostatin, which contributes to regulating the production of glucagon and insulin.

Diabetes mellitus

After a meal, insulin transports glucose into cells for energy and promotes the storage of any remaining glucose as glycogen for future use. During times of fasting, glucagon stimulates glycogen to return to its glucose form providing a source of energy. This constant cycle of replenishing glucose stores, then drawing from them between meals, works to keep BGL within the normal range. Diabetes mellitus is a condition where the pancreatic beta cells aren't producing insulin, or the insulin that is being produced is defective. Glucose is

still needed for energy, but cannot enter the cells, and because the cells remain starved for glucose, the alpha cells continue to secrete glucagon. Without the support of insulin, the glucose can't be stored either, so it remains in the blood system, causing a hyperglycemic state. Chronic hyperglycemia can lead to complications such as extremity amputation, blindness, chronic renal failure, heart disease, stroke, hypertension, nervous system disease, and premature death. This article will focus on the classifications of diabetes and three common diabetic emergencies: hypoglycemia, diabetic ketoacidosis and hyperosmolar hyperglycemic nonketotic state.

Type 1 diabetes

Type 1 diabetes was formerly referred to as juvenile-onset or insulin-dependant diabetes mellitus. Although it is most commonly diagnosed in children older than nine months and peaking at twelve years old, type 1 diabetes can occur at any age. It is found in 10 percent of the population.^{5,8,9} It is an autoimmune deficiency disease where the body attacks its own beta cells and destroys them. The cause of this is unknown. At first the body can produce a sufficient amount of insulin to keep up with demand, but eventually mass destruction of the beta cells results in patients needing constant insulin injections to maintain an appropriate BGL.

Historically, it was thought Type 1 diabetes had an abrupt onset, but new studies dispute this claim.^{5,8} Islet cell auto-antibodies can appear in the system years before any symptoms first appear, and the older a person is, the longer this preclinical period can last.^{5,8} This can result in patients being misdiagnosed.⁵

While the etiology behind the

development of Type 1 diabetes is unclear, there appears to be a genetic link. Studies show a person is two to three times more likely to develop Type 1 diabetes if their father has it than if their mother does.^{10,11,12}

Additional risk factors appear to include the absence of breast-feeding, diet, viral infection and socioeconomic status. There also appears to be a seasonal link, as it is diagnosed more often in the winter months than in the summer.⁵

Polydipsia, polyuria, and polyphagia (also called the three poly's) are classic symptoms typically associated with Type 1 diabetes, others include unexplained weight loss, irritability, poor wound healing, dizziness and blurred vision. As the glucose levels in the blood increase, water is drawn out of the cells through osmosis. This increase in volume subsequently raises glomerular filtration rate (GFR) in the kidneys leading to increased urination with glucose appearing in the urine. This fluid shift causes a decrease in extravascular water, leaving the patient with a "thirsty" feeling. Fatty acids are metabolized for energy because the body can't use the circulating glucose, this leads to the weight loss and feeling of hunger.

Type 2 diabetes

Type 2 diabetes was formerly referred to as adult onset or non-insulin-dependent diabetes mellitus. This is the most common form of diabetes. It is diagnosed most often in adults over 40 years old, but can occur at any age.^{6,9} Its main characteristic is a cellular insulin resistance. This causes the beta cells to secrete increased amounts of insulin in an effort to keep up with the demand. The pancreas begins to secrete less insulin, the timing of insulin release becomes abnormal, and the body can no longer

keep up with demand.¹² These patients will still be able to secrete some insulin, but may not be able to provide an adequate amount, meaning a number of Type 2 patients may need to take insulin.

The development of Type 2 diabetes is directly linked to obesity because metabolic control in these individuals requires a larger amount of insulin, explaining the increase in diagnosis in younger adults and children.^{9,13}

Other risk factors for developing Type 2 diabetes include a history of gestational diabetes; inactivity; a diet high in fat; hypertension; polycystic ovary disease; increased alcohol intake; and a family history of Type 2 diabetes.^{5,12,13}

While some patients may show the classic signs and symptoms associated with Type 1, usually they are vague and nonspecific and include pruritis (severe itching), fatigue, visual changes, recurrent infections and paresthesias (weakness/numbness). For this reason many people have no idea they are affected by diabetes. The American Diabetes Association estimates that 6.2 million Americans are unaware they have the disease.¹ Type 2 diabetes is easier to control than Type 1 and can usually be controlled with a proper diet combined with exercise, and oral medications that can work to increase both insulin secretion and cellular sensitivity to it. However, as previously mentioned, some patients require daily insulin injections.

Two other classifications

While Type 1 and Type 2 diabetes are the most common forms, two other classifications exist: secondary diabetes and gestational diabetes.

Gestational diabetes is present only during pregnancy, but can predispose women to the development of Type 2 diabetes, it affects about 4 percent of pregnancies.^{1,12} It usually appears

in the mother late in pregnancy.¹⁴ Women suffering from gestational diabetes are at an increased risk for other pregnancy-related complications including preeclampsia, in utero fetal death, spontaneous abortion and macrosomia (“fat” baby). Macrosomia occurs because the fetus gets more glucose from the mother than it needs so it is stored as fat. These newborns are at an increased risk for hypoglycemia and breathing difficulties. The cause of gestational diabetes is unknown and it usually disappears after the woman gives birth.

Secondary diabetes only makes up about one percent of all diabetic cases.¹² It is usually precipitated by factors such as pancreatitis, other pancreatic diseases, hormonal disease, malnutrition and chemical agents.

Diabetic ketoacidosis (DKA)

DKA occurs predominantly in patients with Type 1 diabetes, but has been known to rarely occur in those with Type 2, typically in the presence of a coexisting acute illness.^{12,15} It is an acute, life-threatening emergency associated with very high serum glucose levels and no insulin. Due to the lack of insulin the body’s cells begin to starve, and after two or three days the body starts breaking down adipose tissue and proteins in an attempt to produce a usable energy source. This process is known as glyconeogenesis. The by-product of this process is an acid referred to as ketoacids. The increase in circulating acids causes blood pH to fall leading to metabolic acidosis.

The leading cause of DKA in diabetics is infection; it can also be a result of other illnesses, trauma, and stress. During these times, the body’s sympathetic nervous system kicks in attempting to protect itself.

The “fight or flight” response raises blood pressure, increases heart rate, and increases cardiac output. All this activity increases energy demand, and epinephrine promotes the conversion of stored glycogen to glucose to satisfy this energy supply. Diabetics taking daily insulin injections are on a controlled dose so this increase in blood sugar levels could be enough to cause hyperglycemia. Compounding this problem, many patients may not take their insulin when they are sick, under the erroneous rationale that they haven’t been eating anything so they shouldn’t need it. DKA will also occur in otherwise healthy diabetics if they stop taking their regular doses of insulin or have an increased dietary intake.

Initial symptoms of hyperglycemia include the three poly’s, weight loss and fatigue – the same symptoms seen in untreated, undiagnosed Type 1 diabetics. Hyperglycemia progresses to DKA with the production of ketoacids. As they accumulate, the patient’s respirations change in an attempt to reduce acidosis by blowing off carbon dioxide. Kussmaul respirations are quick and deep, similar in presentation to hyperventilation, and will have a fruity odor due to acetone.

Acidosis causes intracellular potassium to shift outside the cells, and the increasing diuresis results in the body losing large amounts of potassium and sodium. These electrolyte imbalances leave DKA patients prone to cardiac arrhythmias, muscle weakness and seizures. The increased urination, combined with patient nausea and vomiting, leads to dehydration, hypovolemia and shock. This results in tachycardia, and a weak thready pulse. However their extremities will often be warm and dry. The glyconeogenesis also produces two different types of prostaglandins as by-products and these cause

paradoxical vasodilation. Other signs and symptoms include generalized abdominal pain, poor skin turgor, dry mucous membranes, an altered level of consciousness and weight loss.

Prehospital treatment for DKA is focused on stabilizing the patient, fluid resuscitation and correcting the acid/base imbalances. If the patient is alert enough to maintain their own airway, high concentration oxygen is administered via a nonrebreather. A detailed history is obtained including insulin administrations or other medications, food intake, onset of symptoms, recent illnesses, and any alcohol or drug use. A full set of vital signs is taken, including BGL and an electrocardiogram to check for cardiac disturbances.

To correct hypovolemia a saline bolus of one liter normal saline can be administered through at least one large bore IV, more than one liter may be required if the hypovolemia is severe enough. Place the adult patient in Trendelenburg if they are displaying symptoms of shock.

The main cause of death in pediatric patients with DKA is cerebral edema, and this serious complication is believed to be linked to overly aggressive fluid resuscitation.¹⁶ To protect against this, the recommended initial bolus for pediatric patients is 10 ml/kg/hr given in the first two hours, with a maximum of 50ml/kg given during the first four hours.^{16,17}

As with all fluid resuscitation, the patient will need to be monitored for pulmonary edema development. Unconscious patients or patients unable to protect their own airway will require intubation. Re-check blood pressure often to monitor the patient's response to fluid replacement, and be ready to treat for seizures. It is rare that a DKA patient will be completely unresponsive, so remember to assess

for other causes if the patient presents in that state.

All these patients will need to be transported to the emergency room regardless of the level of consciousness. Definitive treatment for DKA includes insulin and potassium chloride administration in hospital, some patients may also receive parenteral magnesium sulfate and sodium bicarbonate. However, magnesium sulfate is rarely required and the role sodium bicarbonate plays in reversing metabolic acidosis in these patients is under debate.¹²

Hyperosmolar hyperglycemic nonketotic state (HHNK)

HHNK is very similar to DKA in that it is a life-threatening emergency caused by severe hyperglycemia. It is clinically different from DKA in that ketoacids are not formed and acidosis is usually minimal. This is likely due to the patient producing enough insulin to adequately prevent glyconeogenesis.

The typical HHNK patient is elderly with poorly controlled or undiagnosed Type 2 diabetes. They often present with many symptoms which mimic those of DKA, including polydipsia, polyuria, weakness, weight loss, tachypnea (not Kussmaul respirations) and tachycardia. Volume loss is significant in these patients due to increased urination and electrolyte imbalances, so look for signs of hypovolemia and dehydration including dry mucous membranes, orthostatic hypotension and sunken eyes. Patients may be able to keep up with volume losses if they have significant access to drinking water. If extreme hyperglycemia is present, the patient can also present with central nervous system complications including generalized seizures and coma.

HHNK is most likely to affect patients who take diuretic medication,

have a recent history of infections like pneumonia or urinary tract infections, and often don't have easy access to water. They may be bedridden and have difficulties communicating. HHNK has a higher rate of mortality than DKA, most likely due to the patient populations in which it is often seen.¹²

Prehospital treatment for HHNK focuses on stabilizing the patient and correcting any existing fluid loss. Make sure the patient is well oxygenated and establish at least one large-bore IV to administer at least a one liter normal saline bolus. Follow the same treatment guidelines as those for DKA.

Hypoglycemia

Hypoglycemia is defined as a BGL of less than 80 mg/dl with symptoms consistent with a diagnosis of hypoglycemia which resolve after glucose administration. However symptoms usually don't appear until BGL are less than 60 mg/dl.^{9,12}

The body's central nervous system (CNS) requires a constant supply of glucose to function properly and has a reservoir which will only provide enough energy for a few minutes of normal brain function. In diabetic patients hypoglycemia is usually caused by taking too much insulin (accidentally or intentionally), decreasing dietary intake, and an increase in vigorous physical activity. It is also tied to liver disease, sepsis, chronic alcohol intake and certain antibiotics.

The patient often presents with the CNS complications you would expect when the brain is glucose deprived, including nervousness, irritability, seizures and altered levels of consciousness ranging from confused or combative to lethargic and unresponsive. Other symptoms include weakness and lack of coordination, combined with an aggressive and

belligerent behavior. These patients may appear to be intoxicated, causing a delayed or completely missed diagnosis. Everyone presenting with an altered mental status needs to have their BGL checked. Even non-diabetic patients can experience a hypoglycemic episode. The causes for this are outside the scope of this article.

Treatment consists of glucose administration to correct the hypoglycemia. If the patient is alert and oriented enough to maintain their airway they can be given oral glucose 15g or an alternative such as a drink with sugar added. If the patient is unable to obtain their own airway 1mg of glucagon can be given intramuscularly or subcutaneously, or establish an IV and administer 1g/kg of a 50 percent dextrose in water solution (D50). Due to the drug's ability to cause thrombophlebitis, the dose for pediatric patients is 1cc/kg of a 25 percent solution, and a 10 percent solution is used in neonates.¹⁸ Of course, all doses are dependent on the paramedic's local protocols.

When administering D50, the paramedic should consider administering thiamine as well, if it's in their protocols. Any patient with a history of alcohol intoxication or suspected malnourishment could be thiamine deficient. Studies have shown that administering a D50 bolus in these circumstances can precipitate Wernicke's encephalopathy (an inflammatory disease affecting the brain). However, never withhold glucose because you don't administer thiamine.¹² The normal dose of thiamine is 100 mg given intravenously over two minutes.

Many patients treated for hypoglycemia are well aware of their condition and will refuse transport, and others will want to go for physician evaluation. The paramedic should

follow local protocol on patient refusals. If no transport is required, it is important that the patient eats a meal containing complex carbohydrates, as glucose is a simple sugar which is utilized quickly.

Conclusion

Diabetes mellitus affects over 20 million people in the U.S., and with this number on the rise medics are likely to encounter diabetic patients with these acute life-threatening metabolic disturbances. It is important for emergency medical providers to review and familiarize themselves with the symptoms and treatments for these conditions.

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