Fluid and Electrolyte Therapy in Diabetic Ketoacidosis

Elizabeth Thomovsky, DVM, MS

KEYWORDS

• Diabetic ketoacidosis • Insulin • Crystalloid fluid • Hyperglycemia • Acidosis
• Sodium • Potassium • Phosphorus

KEY POINTS

- Treatment of diabetic ketoacidosis is relatively straightforward in its approach.
- The difficulty comes in fine-tuning the basic treatment protocol to each animal.
- Using crystalloid fluids in addition to insulin therapy with frequent rechecks of blood glucose, electrolytes, and blood pH, resolution of the hyperglycemia and other abnormalities is almost always successful.

INTRODUCTION

Diabetic ketoacidosis (DKA) is a complication of diabetes mellitus commonly encountered in dogs and cats. This article presents an approach to fluid and electrolyte therapy for DKA. Although an extensive discussion of the pathophysiology and clinical presentation is beyond the confines of this article, this article will briefly touch on the important points related to this disease before discussing details of fluid and electrolyte management.

PATHOPHYSIOLOGY OF DIABETIC KETOACIDOSIS

Diabetes mellitus refers to a deficiency of insulin in the body that can be relative or absolute.[1,2] Regardless of the exact reason for the deficiency of insulin, the result is that the diabetic dog or cat is unable to move glucose from the bloodstream into the cells to fuel cellular metabolic processes. In response, the cells of the body begin to mobilize alternative energy sources such as fats and proteins to provide fuel for metabolism. See **Fig. 1**A, B for more details.[3,4]

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Department of Veterinary Clinical Sciences, College of Veterinary Medicine, Purdue University, 625 Harrison Street, West Lafayette, IN 47906, USA
E-mail address: ethomovs@purdue.edu

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In this climate of cellular demand for energy, the body is initially able to supply enough energy to the cells, largely through metabolism of fats. However, in the process of breaking down fats to make energy, ketoacids are also formed in excess.[2] Although some of the ketoacids are used by the myocardium, skeletal muscle, kidney cells, and brain, those remaining need to be excreted by the kidneys.[2]

In most cases, ketoacids are formed in excess when cellular energy demand increases above normal.[5] In diabetic patients, this often occurs when hormones such as epinephrine, glucagon, cortisol, and growth hormone are produced. These hormones may be produced when there is a concurrent disease process but can simply be produced when the body perceives that it requires more energy in the cells.[5] Concurrent diseases range from the relatively benign (urinary tract infection) to more severe disorders such as pancreatitis or neoplasia. These ketogenic hormones increase fatty acid breakdown (glucagon), further decrease insulin's efficacy (growth hormone, epinephrine, and cortisol), and increase protein breakdown (cortisol and epinephrine).[5]

Oxidation of fats to form ketone bodies liberates carboxylic acids that release hydrogen ions.[2] Therefore, overproduction of ketone bodies also leads to an overproduction of hydrogen ions, thus decreasing the blood pH and leading to acidosis. A diabetic patient can be ketotic without acidosis if the bicarbonate buffering system in the body can bind to and buffer the hydrogen ions. When the amount of hydrogen ions created exceeds the bicarbonate buffering system's ability to bind hydrogen, acidosis results.[2]

Contributing to the development of acidosis (and hence DKA) is the mechanism of ketoacid excretion in the kidneys. To be excreted from the kidneys, the ketoacids combine with sodium found in the extracellular fluid (blood and interstitial fluid).[6] Hydrogen ions are then used by the body to replace the sodium ions in the extracellular fluid, further decreasing the pH of the bloodstream and interstitial tissues.[1,6]

NONPHARMACOLOGIC TREATMENT OPTIONS FOR DIABETIC KETOACIDOSIS

Once a patient has been diagnosed with DKA by a combination of documented hyperglycemia, glucosuria, ketonuria, and acidemia, the first order of business is to initiate treatment. The mainstays of treatment of ketoacidosis are fluids and insulin therapy. Obviously, if there is another concurrent disorder in the dog or cat that has led to the development of DKA, such as a urinary tract infection, pancreatitis, or any other disease, specific treatment of that condition should be instigated as well. This article focuses on the fluid therapy aspects and briefly touches on insulin therapy; veterinarians are urged to consult other resources for information about treating disorders concurrent with DKA.

OVERVIEW OF FLUID THERAPY IN DIABETIC KETOACIDOSIS

Fluids are given to patients with DKA for several reasons:

- Dehydration (see **Box 1** for the mechanism of this change in DKA)
- Hypovolemia (see **Box 1**)
- Improve glomerular filtration in the kidneys (see **Box 1**)
  - Increase excretion of glucose through the kidneys
  - Increase excretion of ketoacids and hydrogen ions through the kidneys
  - Decreases acidosis
- Resolve hypernatremia (see **Box 2** for mechanism of electrolyte changes)
- Supply potassium (see **Box 2**)
- Supply phosphorus if indicated (see **Box 2**).