

Renal Tubular Acidosis

National Kidney and Urologic Diseases Information Clearinghouse



U.S. Department
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What is renal tubular acidosis (RTA)?

Renal tubular acidosis (RTA) is a disease that occurs when the kidneys fail to excrete acids into the urine, which causes a person's blood to remain too acidic. Without proper treatment, chronic acidity of the blood leads to growth retardation, kidney stones, bone disease, chronic kidney disease, and possibly total kidney failure.

The body's cells use chemical reactions to carry out tasks such as turning food into energy and repairing tissue. These chemical reactions generate acids. Some acid in the blood is normal, but too much acid—acidosis—can disturb many bodily functions. Healthy kidneys help maintain acid-base balance by excreting acids into the urine and returning bicarbonate—an alkaline, or base, substance—to the blood. This “reclaimed” bicarbonate neutralizes much of the acid that is created when food is broken down in the body. The movement of substances like bicarbonate between the blood and structures in the kidneys is called transport.

One researcher has theorized that Charles Dickens may have been describing a child with RTA in the character of Tiny Tim from *A Christmas Carol*. Tiny Tim's small stature, malformed limbs, and periods of weakness are all possible consequences of the chemical imbalance caused by RTA.¹ In the story, Tiny Tim recovers when he receives medical treatment, which would likely have included

sodium bicarbonate and sodium citrate, alkaline agents to neutralize acidic blood. The good news is that medical treatment can indeed reverse the effects of RTA.

How is RTA diagnosed?

To diagnose RTA, doctors check the acid-base balance in blood and urine samples. If the blood is more acidic than it should be and the urine less acidic than it should be, RTA may be the reason, but additional information is needed to rule out other causes. If RTA is the reason, additional information about the sodium, potassium, and chloride levels in the urine and the potassium level in the blood will help identify which type of RTA a person has. In all cases, the first goal of therapy is to neutralize acid in the blood, but different treatments may be needed to address the different underlying causes of acidosis.

What are the types of RTA?

Type 1: Classical Distal RTA

Type 1 is also called classical distal RTA. “Distal,” which means distant, refers to the point in the urine-forming tube of the kidney where the defect occurs—relatively distant from the point where fluid from the blood enters the tiny tube, or tubule, that collects fluid and wastes to form urine.

This disorder may be inherited as a primary disorder or may be one symptom of a disease that affects many parts of the body. Researchers have discovered abnormal genes responsible for the inherited forms of the disease. More often, however, classical distal RTA occurs as a result of systemic diseases—

¹Lewis D. What was wrong with Tiny Tim? *American Journal of Diseases of Children*. 1992;146(12):1403–1407.

diseases that affect many organ systems—like the autoimmune disorders Sjögren’s syndrome and lupus, which also attack the distal tubule.

Other diseases and conditions associated with classical distal RTA include sickle cell anemia, hyperparathyroidism, hyperthyroidism, chronic active hepatitis, primary biliary cirrhosis, a hereditary form of deafness, analgesic nephropathy, rejection of a transplanted kidney, renal medullary cystic disease, obstructive uropathy, and chronic urinary tract infections. Many of these conditions cause abnormal calcium deposits to build up in the kidney and impair distal tubule function.

A major consequence of classical distal RTA is a low blood potassium level. The level drops if the kidneys excrete too much potassium into urine instead of returning it to the blood supply. Because potassium helps regulate nerve and muscle health and heart rate, low levels can cause extreme weakness, irregular heart-beat, paralysis, and even death.

Untreated classical distal RTA causes growth retardation in children and progressive kidney and bone disease in adults. Restoring normal growth and preventing kidney stones are the major goals of therapy. If acidosis is corrected with sodium bicarbonate or sodium citrate, then low blood-potassium, salt depletion, and calcium leakage into urine will be corrected. This alkali therapy also helps decrease the development of kidney stones and stabilizes kidney function so kidney failure does not progress. Infants may need potassium supplements, but older children and adults rarely do because alkali therapy prevents the kidney from excreting potassium into the urine.

Type 2: Proximal RTA

Type 2 is also called proximal RTA. The word “proximal,” which means near, indicates that the defect is closer to the point where fluid and wastes from the blood enter the tubule.

This form of RTA occurs most frequently in children as part of a disorder called Fanconi’s

syndrome. The features of Fanconi’s syndrome include the abnormal excretion of glucose, amino acids, citrate, and phosphate into the urine, as well as vitamin D deficiency and low blood-potassium.

Proximal RTA can also result from inherited disorders that disrupt the body’s normal breakdown and use of nutrients. Examples include the rare disease cystinosis, in which cystine crystals are deposited in bones and other tissues; hereditary fructose intolerance; and Wilson disease.

Proximal RTA also occurs in patients treated with ifosfamide, a drug used in chemotherapy. A few older drugs—such as acetazolamide or outdated tetracycline—can also cause proximal RTA. In adults, proximal RTA may complicate diseases like multiple myeloma, or it may occur in people who experience chronic rejection of a transplanted kidney.

When possible, identifying and correcting the underlying causes are important steps in treating the acquired forms of proximal RTA. The diagnosis is based on the chemical analysis of blood and urine samples. Children with this disorder would likely receive large doses of an oral alkali, such as sodium bicarbonate or potassium citrate, to treat acidosis and prevent bone disorders, kidney stones, and growth failure. Correcting acidosis and low potassium levels restores normal growth patterns, allowing bone to mature while preventing further renal disease. Vitamin D supplements may also be needed to help prevent bone problems.

Type 3

Type 3 is rarely used as a classification because it is now thought to be a combination of type 1 and type 2.

Type 4: Hyperkalemic RTA

Type 4 is also called hyperkalemic RTA and is caused by a generalized transport abnormality of the distal tubule. The transport of electrolytes such as sodium, chloride, and potassium that normally occurs in the distal

tubule is impaired. This form is distinguished from classical distal RTA and proximal RTA because it results in high levels of potassium in the blood instead of low levels. Either low potassium—hypokalemia—or high potassium—hyperkalemia—can be a problem because potassium is important in regulating heart rate.

Type 4 RTA occurs when blood levels of the hormone aldosterone are low or when the kidneys do not respond to it. Aldosterone directs the kidneys to regulate the levels of sodium, potassium, and chloride in the blood. Type 4 RTA also occurs when the tubule transport of electrolytes such as sodium, chloride, and potassium is impaired due to an inherited disorder or the use of certain drugs.

Drugs that may cause type 4 RTA include

- diuretics used to treat congestive heart failure such as spironolactone or eplerenone
- blood pressure drugs called angiotensin-converting enzyme (ACE) inhibitors and angiotensin receptor blockers (ARBs)
- the antibiotic trimethoprim
- the antibiotic pentamidine, which is used to treat pneumonia
- an agent called heparin that keeps blood from clotting
- a class of painkillers called nonsteroidal anti-inflammatory drugs (NSAIDs)
- some immunosuppressive drugs used to prevent rejection

Type 4 RTA may also result from diseases that alter kidney structure and function such as diabetic nephropathy, HIV/AIDS, Addison's disease, sickle cell disease, urinary tract obstruction, lupus, amyloidosis, removal or destruction of both adrenal glands, and kidney transplant rejection.

For people who produce aldosterone but cannot use it, researchers have identified the

Points to Remember

- Renal tubular acidosis (RTA) is a disease that occurs when the kidneys fail to excrete acids into the urine, which causes a person's blood to remain too acidic.
- Without proper treatment, chronic acidity of the blood leads to growth retardation, kidney stones, bone disease, chronic kidney disease, and possibly total kidney failure.
- If RTA is suspected, additional information about the sodium, potassium, and chloride levels in the urine and the potassium level in the blood will help identify which type of RTA a person has.
- In all cases, the first goal of therapy is to neutralize acid in the blood, but different treatments may be needed to address the different underlying causes of acidosis.

genetic basis for their body's resistance to the hormone. To treat type 4 RTA successfully, patients may require alkaline agents to correct acidosis and medication to lower the potassium in their blood.

If treated early, most people with any type of RTA will not develop permanent kidney failure. Therefore, the goal is early recognition and adequate therapy, which will need to be maintained and monitored throughout the person's lifetime.

Hope through Research

The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) conducts and supports research into many kinds of kidney disease, including renal tubular acidosis. NIDDK-supported researchers are exploring

the genetic and molecular mechanisms that control acid-base regulation in the kidney. These studies will point the way to more effective treatments for RTA.

Participants in clinical trials can play a more active role in their own health care, gain access to new research treatments before they are widely available, and help others by contributing to medical research. For information about current studies, visit www.ClinicalTrials.gov.

For More Information

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Publications produced by the Clearinghouse are carefully reviewed by both NIDDK scientists and outside experts. This publication was reviewed by Thomas DuBose Jr., M.D., Wake Forest University Baptist Medical Center.

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