

Chapter 5

Ketone Testing

KETONES

Ketones are chemicals which appear in the urine and blood when body fat is used for energy. Ketones are a side product of fat breakdown (see Chapter 15).

Body fat is used for energy...

- when there is not enough insulin to allow sugar to be burned as energy in the body.
- when not enough food has been eaten to provide energy.

Ketone testing is **VERY** important. A method of testing for ketones must be kept in the home (and taken on trips) at all times.

We usually teach families how to do the urine ketone test on the first day of diagnosis of diabetes. Frequent urine ketone tests are important in the first few days after diagnosis to determine if enough insulin is being given to turn off ketone production. **Turning off ketone production is the first goal in the treatment of newly diagnosed diabetes managed in the outpatient setting.** This usually takes one or two days after starting insulin.

The second goal is to lower blood sugar levels (done primarily by turning off internal sugar production in the liver). This usually takes one or two weeks after starting insulin. Giving insulin helps to accomplish both goals.

TOPIC: Monitoring (ketones)

Prevention, Detection and Treatment of Acute Complications (How and when to treat for ketones)

TEACHING OBJECTIVES:

1. Discuss when ketone measurement should be done.
2. Introduce method to be used for measuring ketones.
3. Present the appropriate time to call the healthcare provider.

LEARNING OBJECTIVES:

Learner (parents, child, relative or self) will be able to:

1. Define ketones and the importance of ketone testing.
2. Identify and demonstrate when and how to test for ketones.
3. State the appropriate time to call the healthcare provider.

**Table 1
Comparison of Blood Beta Ketone and Urine Ketone Readings ***

<p>Blood (mmol/L) < 0.6 0.6 to 1.5 1.6 to 3.0 ≥ 3.0</p>	<p>↔ go directly to the E.R. ↔</p>	<p>Urine negative small to moderate usually large very large</p>
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* The blood and urine ketone values do NOT always agree. The urine may have been in the bladder for several hours. The blood levels tell what the ketones are at the moment the test is done. (Also read the second Q and A at the back of this chapter.)

The healthcare provider should be called for all values > 1.0 mmol/L in the blood or if the urine ketones are moderate or large.

REASONS FOR TESTING FOR KETONES

It is important to test for urine or blood ketones because they can build up in the body. This can result in one of the two emergencies of diabetes, acidosis or ketoacidosis (see Chapter 15). In the past, it was only possible to test for urine ketones. The Precision Xtra™ meter is now available to do a home fingerstick test for blood ketones. The diabetes care provider should be notified when the urine ketone test shows moderate or large ketones or if the blood ketone test is above 1.0 mmol/L.

Usually extra insulin is taken to help make the ketones go away. If the ketones are not detected early, they will build up in the body and ketoacidosis will result. This is particularly true during illnesses. Early detection of ketones and the treatment with extra rapid-acting insulin (Humalog/NovoLog/Apidra) can help prevent hospitalizations for ketoacidosis (see Chapter 15). Hospitalizations for ketoacidosis are still listed as the number one reason for hospitalizing children in the U.S. with known diabetes. **It is our belief that these hospitalizations for ketoacidosis are completely preventable. To accomplish this, the ketone testing must be done, the diabetes care provider called when indicated, and extra shots of insulin given.**

WHEN TO TEST FOR KETONES

Ketones must always be checked if the blood sugar is high (above 240 mg/dl [13.3 mmol/L] fasting, or above 300 mg/dl [16.7 mmol/L]) during the day. They must also be checked ANYTIME THE PERSON FEELS SICK OR NAUSEATED (especially if he/she vomits, even once). **If the person is sick, ketones can be present even when the blood sugar is not high.**

CALL YOUR DIABETES CARE PROVIDER NIGHT OR DAY IF MODERATE OR LARGE URINE KETONES ARE PRESENT OR FOR BLOOD KETONES ≥ 1.0 MMOL/L. TELL THE PERSON ANSWERING THE PHONE THAT THE CALL IS URGENT.

People who have been recently diagnosed with diabetes usually need to check ketones twice daily (or more often if they are positive). After the first few days, if all ketone checks have been negative, daily testing of ketones is not needed.

People who take only one insulin injection per day should do routine morning blood or urine ketone tests to see if their insulin is lasting a full 24 hours. Morning ketones will usually be present if an insulin injection is needed in the evening.

WHAT TEST MATERIALS ARE AVAILABLE?

Testing for Urine Ketones

The two strips that are most frequently used in checking for urine ketones are the Ketostix® and the Chemstrip K®. If the child is not yet toilet trained, it is usually best to press a test strip (see section on Ketostix) firmly against the wet diaper. It is also possible to place cotton balls in the diaper where the diaper is wettest. Drops of urine can then be squeezed from the cotton ball.

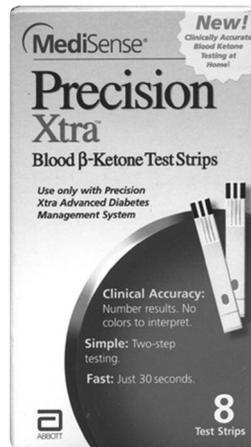
Ketostix

The Ketostix (or Ketodiasix® with the sugar check) is reliable for urine testing **IF THEY ARE CAREFULLY TIMED WITH A SECOND HAND ON A CLOCK.** The Ketostix are cheaper than the Ketodiasix and it is not necessary to do the urine sugar, as a blood sugar is more accurate.

There is a place on the side of the bottle to write the date the bottle is opened. The strips are then good for six months. Individually foil-wrapped Ketostix will not expire for two or three years. This gets around the problem of having to throw any unused Ketostix away once the bottle has been open for six months. Ask your pharmacist to order them if he/she does not have them. The Bayer product number for ordering is 2640 (20 foiled strips).

The following procedure must be followed exactly:

1. Completely cover the colored square on the end of the strip by dipping into FRESH urine. Then immediately remove the strip from the urine. We prefer that the urine be collected in a cup and that the strip then be timed and read by two people. This prevents errors due to color blindness or psychologic factors. A supply of small paper cups might be kept in the bathroom medicine cabinet for this purpose.



2. Gently tap the edge of the strip against the side of the urine container to remove excess urine.
3. Compare the test area closely with the corresponding color chart. The timing is very important. **READ KETONES AT EXACTLY 15 SECONDS AFTER DIPPING THE STRIP. HOLD THE STRIP CLOSE TO THE COLOR BLOCK AND MATCH THE COLORS CAREFULLY.** These tests must always be timed with the second hand of a clock. Counting is NOT accurate enough.
4. Immediately record the result of the ketone test as negative, small (15), moderate (40), large (80) or large-large (160) in the notebook so that it is not forgotten.

Chemstrip K

The Chemstrip K (or Chemstrip uGK® with the urine glucose check) is the second method that can be used to check for urine ketones. The only difference from the instructions for the Ketostix is in the timing. Chemstrip K must be timed for one minute. Read as negative, small, moderate or large at exactly one minute.

Testing for Blood Ketones

The Precision Xtra Meter is the only meter which allows testing for blood beta ketones. The test strips can be purchased in boxes of eight foil-wrapped beta ketone strips (see scan of box). Although the blood ketone strips are more expensive, they do not have to be replaced (like Ketostix) every six months. Thus, the cost is not all that different. When insurance will not cover the cost of the blood strips, some people screen with the urine strip and just do the blood test when the urine test is moderate or large.

Steps:

1. The red control strip must first be inserted to calibrate for beta ketones. Make sure the calibration code on the red calibration strip matches the code on the ketone strip.
2. Open a strip and place it into the meter with

the three black bars facing up. Push the strip completely into the test port of the meter until it stops.

3. After washing and drying the hand, lance the finger.
4. Place a drop of blood into the purple hole on the strip.
5. The result is then displayed on the meter in 10-20 seconds (new improved meter).

We suggest interpreting the readings as follows (in mmol/L):

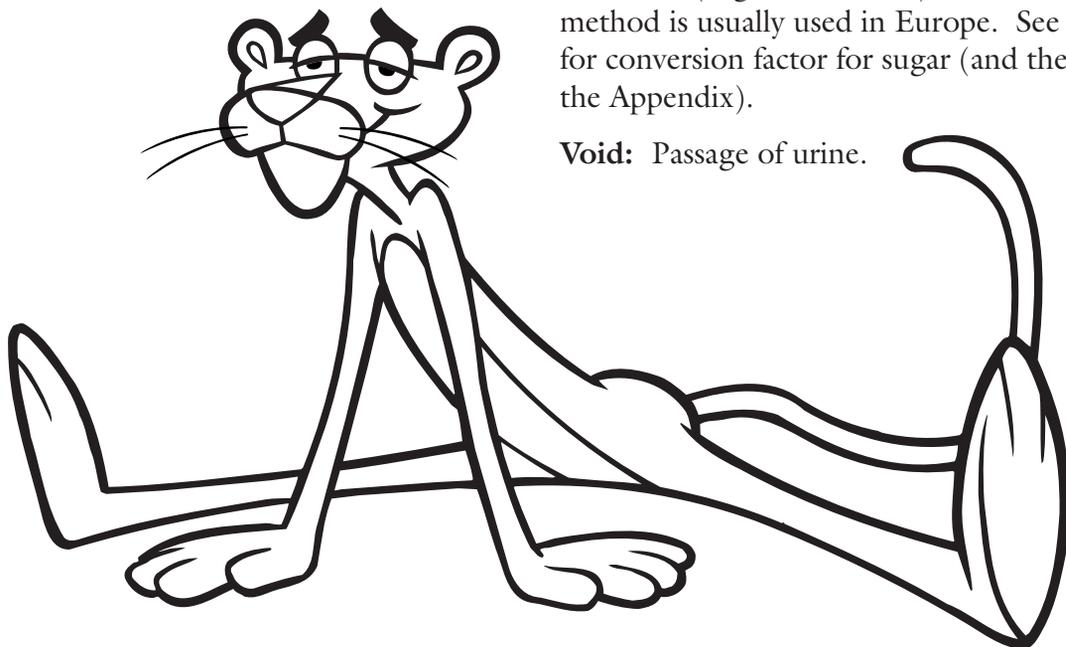
< 0.6 = normal

0.6 – 1.0 = slightly elevated. Drink extra fluids.

1.0 – 3.0 = serious and call healthcare provider and state the call is urgent. Take extra rapid-acting insulin and drink extra fluids.

> 3.0 = **Go directly to the Emergency Room. Have someone take you!**

A doctor in Boston (Dr. Lori Laeffel) showed that youth who were sick were 53 percent likely to check urine ketones and 93 percent likely to check blood ketones. The saving of one hospitalization from treating ketones earlier would save 5,000 to 10,000 dollars.



DEFINITIONS

Chemstrip K: Strips for measuring urine ketones (acetone). They are also available as Chemstrip uGK (for urine ketones and sugar).

Ketoacidosis (Acidosis): What happens in the body when not enough insulin is available. Blood sugar is usually high at this time. Moderate or large ketones are present in the urine as well as in the body. This is the subject of Chapter 15.

Ketostix: Strips for measuring urine ketones (acetone). They are also available as Ketodiastix (for urine ketones and sugar).

Ketones (Acetone): The chemicals that appear when not enough insulin is present and fat is broken down. Acetest tablets, Ketostix or Chemstrip K measure urine ketones. The Precision Xtra measures blood beta ketones.

mg/dl: Milligrams of material in a measured amount (100cc). Blood sugar (glucose) levels are expressed in these terms in the U.S., but they are usually expressed as mmol/L in Europe. It is possible to convert mg/dl to mmol/L by dividing by 18 (or multiplying by 0.0555). The opposite is done to go from mmol/L to mg/dl. A conversion table for glucose values is in the Appendix.

mmol/L: Method of measuring the amount of a material (sugar or ketones) in the blood. This method is usually used in Europe. See mg/dl for conversion factor for sugar (and the table in the Appendix).

Void: Passage of urine.

QUESTIONS AND ANSWERS FROM NEWSNOTES

Q Why are you now advising that we buy the foil-wrapped rather than the bottles of Ketostix for measuring urine ketones?

A You will note that on the side of a bottle of Ketostix, you are asked to write in the date the bottle is opened and to dispose of the bottle six months later. Sometimes people forget to do this. Once the bottle is open, moisture and other factors result in a gradual loss of sensitivity. Often, a flu episode will start in the middle of the night. As one looks at the date on the side of the bottle, if the strips have been open longer than six months, they are unreliable. Similarly, if a date was not recorded, it is usually necessary to assume that the strips have been open more than six months. They then must be discarded. Then one has to go looking for an open pharmacy in the middle of the night. The foil-wrapped Ketostix avoids this problem. They may have an expiration date two years away. The expense is not all that different if one considers replacement of the urine strips every six months.

Ketone measurements are **VERY** important. A method for ketone testing **MUST** be in the home at all times. It is **ONLY** by measuring the ketones that one can know if moderate or large urine ketones or high levels of ketones in the blood are present. If present, the physician must be called immediately. This may prevent a life-threatening episode of ketoacidosis (Chapter 15).

Q We recently obtained a Precision Xtra meter that measures the blood ketones as well as the blood sugars. How do the blood ketone measurements compare with the urine ketone measurements? When do we need to call our doctor or nurse?

A Like a blood sugar measured on a meter, the blood (serum) ketone value gives the ketone level at the time the test is done. The urine ketone measurement, like a urine sugar, can be hours behind. (The urine collected is since the last void.) The blood ketone value has the potential to be better than the urine ketone measurement.

I am not aware of studies comparing the serum ketone (primarily beta-hydroxy butyric acid) with the urine ketone (primarily acetoacetic acid) levels. The company notes that levels below 0.6 (all values are in mmol/L) are considered “normal” levels, in the 0.6 to 1.5 range are considered “moderate” and levels from 1.6 to 3.0 are considered “high” (probably similar to “large” urine ketones). Levels above 3.0 should be considered dangerous with a need to head to a hospital (DKA – Chapter 15). It is most beneficial when sequential blood levels are done throughout the day so that the family can know if values are increasing, staying the same or decreasing. The test is particularly helpful when a person cannot void frequently due to dehydration, or when a person does void for the first time in a number of hours, so that it is not possible to tell if the urine ketone measurement represents the current level. It would be wise to routinely call the diabetes care provider when values above 1.0 are obtained. As an added note, please remember to check the calibration code when you use a new batch of the ketone strips. The red calibration stick needs to match the code on the ketone strip you are using.

It has been shown that youth are more likely to check blood ketones with an illness (93 percent did) than to check urine ketones (only 53 percent did). Finding ketones earlier could save a 5,000 to 10,000 dollar hospitalization (OR A LIFE!).



Who
is low?