

CHAPTER 11:

PREVENTING DKA

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The signs and symptoms of **diabetic ketoacidosis (DKA)**, methods of detection, and treatment are taught at the time of initial diabetes diagnosis. This problem is reviewed here.

CAUSES

Several studies (5, 14) have shown a slight increase in episodes of DKA as a result of insulin pump use. This is because the only insulin being delivered is a rapid-acting insulin. When it is not being delivered through the pump, there is no other insulin present. However, the increase in incidence is not great enough to prevent using insulin pump therapy.

The most common causes that prevent the pump user from receiving insulin are an occluded cannula, a kinked cannula or dislodgement of the infusion set. An occluded cannula occurs when the tubing under the skin becomes clogged, often by blood or other tissue. A kinked cannula acts just like your kinked garden hose by folding and preventing fluid from passing through. These are virtually undetectable from the outside. While there are built in occlusion alarms in the pump, they work on built up pressure in the system. This may take hours to occur, too long to start dealing with the problem. Increasingly elevated blood sugars are a better indicator of trouble. This is why it is important to check a minimum of four times daily. It may be especially problematic to assess during sleep, when no routine checking is performed. Occasionally the pump infusion set will come out (dislodge) resulting in no insulin delivery. There is no alarm to detect this; elevated blood sugars are again the primary indication.

Ketones usually begin to form after approximately three hours with no insulin and build up to high levels after four or five hours. If a pump is disconnected for an athletic event, most people check a blood sugar level every one to two hours and reconnect to take a bolus of insulin if the value is high (e.g., above 180 mg/dl [10 mmol/L]). If a pump is turned off or disconnected, the pump user must remember to reconnect and/or turn it back on. We often suggest keeping the pump on and setting a temporary basal with “0” units of insulin for either one or two hours, so the pump will turn basals back on by itself.

Illnesses (infections) are probably the second most frequent cause of elevated ketone production for people using insulin pumps. It is essential to remember to do the ketone checks at least twice daily with any illness (even if the blood sugar is not high). If blood sugars are elevated with the illness, one might program a temporarily increased basal rate.

Unsuccessful insulin delivery and subsequent rise in ketones may also be caused by a malfunctioning pump, dead batteries, an empty reservoir or denatured insulin. (Insulin spoils if it has gotten too hot or too cold.) It is important to note that while ketones can cause you to feel ill, almost flu-like, it's imperative to err on the side of caution and assume that the initial problem is pump-related rather than an illness. That way you do not fail to treat appropriately in the event it is a pump problem. You can't go wrong by giving an injection and troubleshooting the system first, even if it later turns out that your elevated ketone levels are due to illness.

TABLE 1:

Comparison of Blood Beta Ketone and Urine Ketone Readings*

Blood (mmol/L)	Urine
< 0.6	negative
0.6 to 1.5	small to moderate
1.6 to 3.0	usually large
≥3.0	very large

GO DIRECTLY TO THE E.R.

* 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 check is done.

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.

KETONE DETECTION

The first sign that all is not right may be frequent urination due to high blood sugar. The symptoms (upset stomach, vomiting, fruity odor to the breath, etc.) are similar to those occurring in people who take insulin injections. Anytime the blood sugar is above 240 mg/dl (> 13.3 mmol/L) during the night or 300 mg/dl (> 16.7 mmol/L) during the day, ketones must be checked. Ketones can be measured in the urine, but if a person has just urinated or does not like checking urine, it may be more convenient to do a blood ketone measurement.

Table 1 gives an approximate comparison between blood and urine ketone measurements. These are only approximate as urine can be diluted or concentrated, depending on hydration, and the urine ketones will read lower or higher as a result. Urine can collect in the bladder for many hours and may not reflect the true situation at the time of the check. In contrast, the blood ketone measurement always gives the exact level at the time the check is done. Research has shown that the Precision Xtra® meter (Abbott Diabetes Care) gives accurate blood ketone measurements (15). In addition, the blood ketone meter measures a more important ketone

than the one measured in urine. All people who begin pump therapy at our Center are trained to use the Precision Xtra blood ketone meter. Unfortunately, health insurance often does not cover the blood ketone strips which cost approximately \$4 USD each. The strips typically come individually foil wrapped and so can be stored for extended periods of time. Some people will do an initial screen with urine and only use the blood ketone meter when the urine reads moderate or large. It would be unlikely to ever have an elevated blood ketone measurement unless the urine reading was at the moderate or large level (assuming the urine ketone strips are still good). In addition, it may be very helpful to do a blood ketone check in the middle of the night if the person with diabetes has just voided. Wal-Mart generally carries the blood ketone strips.

TREATMENT

When a pump user has elevated ketones, insulin must be given by syringe until the ketones resolve (see Figure 1). If the cause of the ketones is a problem with the insulin pump or the tubing, additional boluses through the pump will not work to clear the ketones. Always have a syringe readily available. Keep it in your blood

glucose monitoring kit. In the worst case scenario you can draw insulin up out of your reservoir or pod for injection. Extra injections are usually given every two hours. If the insulin dose is determined using the correction factor for an elevated blood sugar, the dose to be given is usually double if the ketone level is high. Elevated ketones cause insulin resistance, so a higher dose of insulin is needed. The infusion set must always be changed when elevated ketones are detected, unless there is another obvious cause (e.g., illness). Even if the infusion set cannula has not come out, it may be bent and not delivering the programmed amount of insulin. There may not always be a sufficient build-up of pressure in the system to cause the pump to alarm.

Drinking extra fluids helps to prevent dehydration and wash the ketones out of the body. If the blood sugar is high (e.g., >180 mg/dl [>10 mmol/L]) fluids without sugar can be consumed. When blood sugars are below this level, it may be necessary to intermittently

include fluids containing sugar (e.g., juice). The blood sugar level must be kept high enough so that insulin can continue to be given until the elevated ketones have returned to normal.

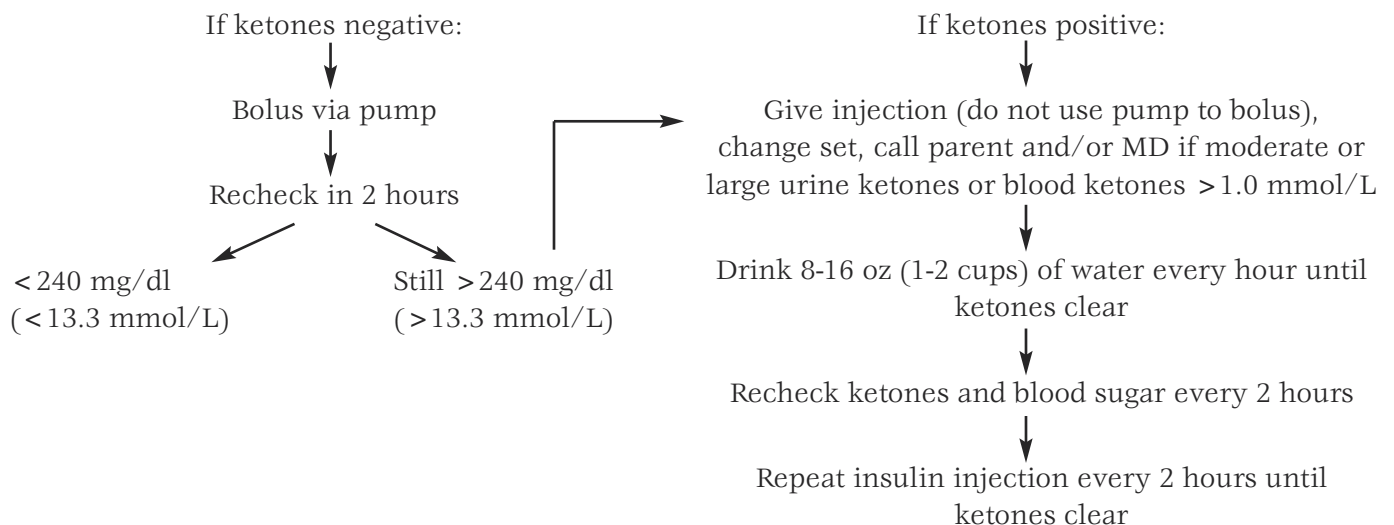
Fortunately, if the person has had good glycemic control (HbA1c in desired range), recovery is usually rapid. However, if vomiting is a problem and dehydration seems likely, it is wise to head to an emergency room. Dehydration is often indicated by a very dry tongue and/or lining of the mouth. Most clinics ask the person/family to call the diabetes care team if moderate or large urine ketones are present or if the blood ketone level is above 1.0 mmol/L. It is wise to notify the diabetes care providers when going to an emergency room, as they may wish to alert the facility. DKA is the leading cause of death in youth with known diabetes, and its occurrence must never be taken lightly.

FIGURE 1:



KETONE TREATMENT TREE

Check for ketones any time blood sugar is > 300 mg/dl (> 16.7 mmol/L) or > 240 mg/dl (> 13.3 mmol/L) two times in a row



TRAVEL

It is important to remember to take ketone checking supplies, an insulin syringe and a new infusion set on any trip (even just overnight). Some people take a vial of basal insulin (Lantus or Levemir) in case the pump malfunctions. The dose is generally the same as the total basal dose used in the pump. It is then important not to restart the pump until 24 hours after taking the last Lantus/Levemir dose. A vial of the rapid-acting insulin, as used in the pump, should always be taken along. However, if it is forgotten, insulin can be drawn out of the pump reservoir or pod to be given by syringe. Needless to say, the diabetes care team emergency numbers should be taken on all trips. Some pump manufacturers offer a loaner pump to use as a back up when traveling out of the country.

SUMMARY

Diabetic ketoacidosis (DKA) can be more frequent for pump users than for people using multiple daily injections. However, if the instructions provided here are followed, severe DKA can be prevented 95% of the time. The pump user/family must be well educated, have supplies available and be constantly alert regarding the possibility of DKA.

DEFINITIONS

DKA: Diabetic ketoacidosis. This occurs when a person with type 1 diabetes does not receive adequate insulin.

Ketones: The breakdown product from fat. They develop when there is not adequate insulin to inhibit fat breakdown. They are acids and can make people very sick.

Precision Xtra meter: A home meter for measuring blood ketones from a drop of blood.

REFERENCES

14. Garg, Chase, et al, Diabetes Tech and Ther. 6; 9, 2004.
15. Rewers, A, Chase, P, et al, Diabetes Tech and Ther. 8; 671, 2006.

