16.1 Causes of Severe Highs and Ketoacidosis

- Onset of Type 1 diabetes
- Severe infection
- Heart attack, stroke, or serious illness
- Insulin doses that are skipped or are too low
- A loose or detached infusion set or pump failure
- Growth spurts in kids and adolescents
- Use of prednisone, other steroid, or an SGLT-2
- Severe stress

16.2 Ketone Test Tools

The ***Freestyle Optium Neo*** glucose and beta ketene monitoring system and the ***Nova Max Plus*** meter kit test glucose in 5 seconds and ketones in 10 seconds using a different strip. A blood ketone level below 0.6 is normal. A level between 0.6 and 1.5 mmol/L shows early ketosis. When a ketone level is above 1.5 mmol/L, you are at a high risk of developing serious DKA.

Bayer Ketostix® or Keto-Diastix® strips test urine ketones. A moderate or large urine ketone test indicates ketosis or severe diabetic ketoacidosis (DKA) is underway. This takes longer to detect.

Ask your clinician for a prescription.

16.3 Ketoacidosis Symptoms

Early Symptoms

- Any unexplained high glucose reading
- Nausea or abdominal pain
- Vague flu-like symptoms
- Increased thirst and dry mouth
- Excessive urination
- Increased hunger
- Excessive tiredness or weakness
- Confusion
- An acetone or fruity odor in the breath

Late Symptoms

- Vomiting
- Severe abdominal pain
- Rapid breathing
- Shortness of breath
- Unconsciousness

Call your physician or go to an emergency room immediately anytime a blood ketone level is 3.0 or higher, large amounts of ketones in urine or blood, or any late sign is present.

16.4 Steps to Treat Ketoacidosis on a Pump

Always check for ketones if you have nausea, an unexplained high glucose, or an unexplained glucose above 250 mg/dL (13.9 mmol/L). If you have moderate or large ketone levels, your pump is not delivering insulin or you have an infection or other serious illness. Follow the directions below for normal to small, or moderate ketone levels.

If blood ketones are less than 1.2 mmol/L or urine ketones are normal or small:	**If blood ketones are above 1.2 or 3.0 mmol/L or urine ketones are moderate or large:**
1. Give a correction bolus with the pump. 2. Drink 8 to 12 ounces of water or non-caloric fluid every 30-60 min. until control is regained. 3. Check your glucose at least every 2 hours when a reading is above 250 mg/dL (13.9 mmol/L). 4. In 2 hours, if your glucose has not fallen and ketones are again small, change the infusion set and site, and follow the procedure to the right. 5. If the glucose is about the same or lower, recheck in another one to two hours and enter this reading into your pump to determine if another correction bolus is needed. 6. If your reading stays high or ketones appear, call your physician and follow the procedure to the right.	***1. Stay hydrated.*** Start with 16 ounces and drink 8 to 12 ounces of non-caloric fluid every 30 min. even if you do not feel thirsty until control is regained. Use water, water with a pinch of Nu-Salt™ to restore potassium levels, or diluted Gatorade. ***2. Give insulin by injection from Table 16.7 until your glucose is below 200 mg/dL (11.1 mmol/L).*** More insulin will be needed with ketones, if basal insulin has been missed, or you have an illness or fever. ***3. Call your doctor if a glucose is over 250 mg/dL (14 mmol/L) with moderate or large ketones.*** ***4. If vomiting begins when ketones are large, immediately call your doctor or go to an ER*** for IV hydration and treatment. Medical treatment is required. Call 911 if no one is available to drive you. 5. Replace the pump insulin cartridge and entire infusion set at a new site, using a new bottle of insulin. Check your pump settings. 6. Once the glucose is less than 200 mg/dL (11.1 mmol/L), ***drink fluids with carbs***, like Gatorade, to avoid having a low glucose and to speed up the fall in ketones.

Thanks to Geri Wood, RN, BSN, CDE and John Stanchfield, MD, of Salt Lake City for their helpful suggestions.

16.5 Prevent Infusion Set Problems

A frequent cause for DKA on a pump is a leaking or detached infusion set. Once insulin delivery stops, ketosis can start in 4 to 5 hours. Always check your infusion set and pump if your glucose is unexpectedly high or above 250 mg/dL (14 mmol/L) without an obvious cause. Anchoring the infusion line with tape eliminates most infusion set problems.

16.7 Approximate Correction Insulin Requirements Based on Blood Ketone Levels (Illness or DKA)

Blood Ketone Level	What It Means	BG = 100-180 mg/dL (5.5-10.0 mmol/L)	BG = 180-250 mg/dL (10.0-14.0 mmol/L)	BG = 250-400 mg/dL (14.0-22 mmol/L)	BG > 400 mg/dL (> 22 mmol/L)
0.5 mmol/L or less	Normal ketones	Give usual correction bolus from pump.	Extra fluid. Give usual correction bolus from pump.	Extra fluid. Give usual correction bolus from pump.	Extra fluid. Give usual correction bolus from pump.
0.6 to 1.5 mmol/L	Ketones are building up. Check infusion set and pump.	Extra carbs and fluid. Give usual bolus doses if infusion set is OK. Recheck in 2-3 hours.	Extra carbs and fluid. Give extra 5% of TDD or 1 u for every 80 lbs (40 kgs). Recheck in 2-3 hours.	Extra fluid. Give extra 10% of TDD or 1 u for every 40 lbs (20 kgs). Recheck in 2-3 hours.	Extra fluid. Give extra 15% of TDD or 1 u for every 25 lbs (12 kgs). Recheck in 2-3 hours.
1.5 to 2.9 mmol/L	Ketoacidosis (DKA) is developing – contact doctor. Check pump, replace infusion set & cartridge.	Extra carbs and fluid. **Inject** extra 5% of TDD or 1 u for every 80 lbs (40 kgs). Recheck in 2-3 hours.	Extra carbs and fluid. **Inject** extra 10% of TDD or 1 u for every 40 lbs (20 kgs). Recheck in 2-3 hours.	Extra fluid. **Inject** extra 15% of TDD or 1 u for every 25 lbs (12 kgs).	Extra fluid. **Inject** extra 20% of TDD or 1 u for every 20 lbs (10 kgs).
At about 3 mmol/L	Severe DKA – call doctor or have someone take you to ER, esp. if vomiting starts. Check pump, replace infusion set & cartridge.	Extra carbs and fluid. **Inject** extra 5% of TDD or 1 u for every 80 lbs (40 kgs). Repeat every 2-3 hrs based on glucose until ketones come down.	Extra carbs and fluid. **Inject** extra 15% of TDD or 1 u for every 25 lbs (12 kgs). Repeat every 2-3 hours until ketones come down.	Extra fluid. **Inject** 20% of TDD or 1 u for every 20 lbs (10 kgs). Repeat every 2-3 hours until ketones come down.	Extra fluid. **Inject** 25% of TDD or 1 u for every 15 lbs (7 kgs). Repeat every 2-3 hours until ketones come down.

The doses above are correction bolus or injection doses only. Larger or smaller doses may be needed.
Basal or long-acting insulin must also be given! **Do not stop basal delivery even if you are not eating.**
Do not go to sleep if you are alone and ketones are 1.5 mmol/L or higher. Call someone to stay with you.
Check your glucose and ketones every 2 hours if your last glucose is above 300 mg/dL (16.7 mmol/L). Above 150 mg/dL in pregnancy.

Modified from International Society for Pediatric and Adolescent Diabetes recommendations [148]

16.6 Injections of a Long-Acting Insulin to Replace Some Basal

Anyone who has had more than one episode of ketoacidosis or who needs to ensure that DKA does not occur because of pregnancy or a heart condition may want to replace some AID basal insulin with a bedtime injection of long-acting insulin for overnight coverage. About half of the day's basal delivery can be replaced with long-acting insulin to ensure enough insulin remains active if an infusion set gets dislodged or other disruption of pump delivery occurs. This lowers the risk of DKA and works well for sports where a pump may need to be disconnected for some time. Talk with your doctor about this.