Sick day management in children and adolescents with diabetes

Dr: P. Eshraghi
Pediatric Endocrinologist
Assistant professor of Mashhad Medical School
بسم الله الرحمن الرحيم
The effects of illness on diabetes

- Children whose diabetes is under good metabolic control should not experience more illness or infections than children without diabetes.

Adult patients with type 1 diabetes in one study had a higher risk of urinary tract, skin, or mucous-membrane infections, but upper respiratory-tract infections were no more frequent than in controls.
There is some evidence of impaired leukocyte function in poorly controlled diabetes.

Pediatric study found low IgG concentrations and reduction in C4B (complement protein 4, variant B) levels to be related to impaired metabolic control.

Many illnesses, especially those associated with fever, raise blood glucose (BG) levels because of higher levels of stress hormones promoting gluconeogenesis and insulin resistance.

Illness increases ketone body production due to inadequate insulin levels.
Illness associated with vomiting and diarrhea (eg. gastroenteritis) may lower BG. Decreased food intake, poor absorption and a slower emptying of the stomach during gastroenteritis may contribute to the hypoglycemia.

Sometimes there are increased insulin requirements during the incubation period of an infection for a few days before the onset of the illness. The increased need for insulin may persist for a few days after the illness has passed, due to insulin resistance.
General principles:

- Never stop insulin
- The insulin dose may need to be increased or decreased
- More frequent monitoring
If episodes of hyperglycemia, ketosis, and vomiting recur, with or without infection, it should be recognised that this may be due to omission or inadequate administration of insulin. Insulin omission is particularly problematic during adolescence.

BG should be monitored at least every 3–4 hours including through the night and sometimes every 1–2 hours.
Ketones

- **Ketones accumulate** because of increased lipolysis, increased ketogenesis and decreased ketone body utilization due to low insulin levels.
- **Urine strips** measure acetoacetate (AcAc) while **blood strips** measure beta-hydroxybutyrate (BOHB). In acute ketoacidosis, the ketone body ratio (BOHB:AcAc) rises from normal (1:1) to 10:1 or more.
Ketones

- The frequently employed nitroprusside test only detects AcAc in blood and urine.
- BloodBOHB > 0.5 mmoll/l is abnormal in children with diabetes.
- The time delay after a pump stop to diagnosis of ketosis is significantly longer for ketonuria than for plasma ketonemia, and that a urinary ketone test can remain positive more than 24 hrs after resolution of an episode of ketoacidosis in over half of patients studied.
ketones

- There may be dissociation between urine ketone (AcAc) and blood BOHB concentrations, which may be increased to levels consistent with DKA when a urine ketone test is negative or shows only trace or small ketonuria.
- Blood BOHB measurements may be especially valuable to prevent DKA in patients who use an insulin pump as only rapid- or short-acting insulin is used in this type of therapy.
ketones

- During resolution of ketosis, blood BOHB normalizes sooner than urine ketones. Monitoring BOHB potentially prevents late hypoglycemia from over treatment with insulin based upon the persistence of ketonuria.
- Blood BOHB monitoring may be especially useful in very young children or when urine specimens are difficult to obtain.
High blood glucose and elevated ketones indicate a lack of insulin. "Starvation blood ketones" are usually below 3.0 mmol/l.

Extra insulin may be given as rapid-acting insulin analogues or short-acting regular insulin, but rapid-acting if available is preferred.

Short-acting insulin can be given intramuscularly to speed up absorption. The ketone level may increase slightly (10–20%) within the first hour after giving extra insulin, but after that it should decrease.
Loss of appetite

- Necessary sick day management supplies include the following:
  - glucose tablets, sweets or candies such as jelly beans, dried fruit, etc to prevent hypoglycemia
  - clean (boiled/purified), cool water to provide hydration.
  - sugar and electrolyte containing fluids such as sports drinks, electrolyte mixtures.
Maintaining hydration

- Hyperglycemia, fever, excessive glycosuria and ketonuria increase fluid losses.
- Elevated levels of ketones, whether associated with low BG (starvation) or high BG (insulin deficiency), contribute to nausea and vomiting, leading to decreased food and fluid intake, further elevated levels of ketones, and dehydration and ketoacidosis.
- Especially in young children with diabetes, intravenous fluids may be required if nausea, vomiting or diarrhea are persistent.
Specific medical advice

- The underlying illness should be treated as it would be for a child without diabetes.
Vomiting may be caused by either

- (i) the illness itself (i.e. gastroenteritis, unclean food or food poisoning, surgical condition or other illness)
- (ii) low BG
- (iii) lack of insulin resulting in high BG and ketosis.
The additional dose recommendation of 0.05 to 0.1 U/kg is a general recommendation for children with standard insulin requirements of approximately 1 U/kg/day.

However, for children who have low requirements or adolescents with insulin resistance and high insulin requirements the % calculations should be used rather than the 0.1 U/kg empiric additional dose.
- When patients in remission phase are ill (during “the honeymoon phase”) there may be a need to increase insulin up to ~1 unit/kg/day very quickly.
- During illness it also may be necessary to increase basal insulin doses, whether by injection therapy or when using an insulin pump. With a pump, temporary basal rate increases of 20% to as high as 50 or 100% may be used until the blood glucose begins to normalize and the ketones clear.
<table>
<thead>
<tr>
<th>Blood ketones mmol/l</th>
<th>Urine ketones</th>
<th>Blood glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.6</td>
<td>Negative or trace</td>
<td>Negative or trace</td>
</tr>
<tr>
<td>0.6–0.9</td>
<td>Trace or small</td>
<td>Trace or small</td>
</tr>
<tr>
<td>1.0–1.4</td>
<td>Small or Moderate</td>
<td>Small or Moderate</td>
</tr>
<tr>
<td>1.5–2.9</td>
<td>Moderate or large</td>
<td>Moderate or large</td>
</tr>
<tr>
<td>≥3.0</td>
<td>Large</td>
<td>Large</td>
</tr>
</tbody>
</table>

**Ketones**

- **<0.6 mmol/l**: Negative or trace. Do not give extra insulin. May need to consider minidoses of glucagon (see Table 2) if <4 mmol (70 mg/dl) are elevated.
- **0.6–0.9 mmol/l**: Trace or small. Check BG and ketones again in two hours. Starvation ketones. Extra carbohydrates and fluid are needed.
- **1.0–1.4 mmol/l**: Small or moderate. Starvation ketones. Extra carbohydrates and fluid are needed. Give ordinary bolus dose.
- **1.5–2.9 mmol/l**: Moderate or large. High levels of starvation ketones. Check BG meter. Recheck BG and ketones. Extra carbohydrates and fluid are needed. May need IV glucose if child cannot eat or drink. **Risk of developing ketoacidosis!** Check BG and ketones every hour.
- **≥3.0 mmol/l**: Large. There is an immediate risk of ketoacidosis if the blood ketone level is ≥ 3.0 mmol/l. Insulin treatment is needed urgently! Consider evaluation of patient at emergency department.

**Blood glucose**

- **<5.5 mmol/l (100–180 mg/dl)**: Do not need to worry.
- **5.5–10 mmol/l (180–250 mg/dl)**: 10–14 mmol/l (250–400 mg/dl)
- **14–22 mmol/l (>400 mg/dl)**: Increase dose of insulin for next meal if BG is still elevated. Give extra 5% of TDD or 0.05 U/kg. Give extra 10% of TDD or 0.1 U/kg. Repeat if needed.
• Target BS: 100-180 mg/dl
• Trace, 1+, 2+ Keton: Insulin if BS > 180
• 3+, 4+ Keton: Insulin if BS > 100
• Trace Keton: CH if BS < 100
• 1+ Keton: CH if BS < 180
• 2+, 3+, 4+ Keton: CH if BS < 250
مثال

سarah ۶ ساله با وزن ۲۰ کیلوگرم مدت ۲ سال است که مبتلا به دیابت نوع یک شده. مصرف انسولین او مدیرش می‌باشد. از NPH, REG سبب ۸ و ۶ شب از از ۴ و ۴ شبه NPH, REG از می‌باشد.

در زمان مبتلا به فارنژیت است. با توجه به قند خون ۲۷ و کتون ادراری trace چه توصیه می‌کنید؟

ساعت بعد قند خون ۱ و کتون ادراری است.
REMEMBER: "S - I - C - K"

- **S** is for blood sugar
- **I** is for insulin. Do not stop insulin and/or diabetes medications.
- **C** is for carbohydrates.
- **K** is for ketone.
After extra insulin has been given, the blood ketone level may temporarily increase by 10–20% for the first hour or two, but should decrease thereafter.

Urine ketones often stay elevated for many hours because of the body’s conversion of blood BOHB into acetoacetate which then can be measured in urine. Acetone can be stored in fat tissue during ketosis, and, along with conversion of BOHB to acetoacetate may contribute to persistent urine ketones despite interruption of ketogenesis with insulin administration.
Infections associated with hypoglycemia

- These infections are often associated with nausea and *vomiting*, with or without diarrhea.
- Attention to urinary output and measurement of *body weight* at home every 4–6 hours can serve as a guide to fluid needs.
- *Reduction* of total daily insulin dose by 20–50% may be required.
Management of Sick Days and hyperglycemia with insulin pump

<table>
<thead>
<tr>
<th>If urine ketones are negative/small or blood ketones &lt;0.6 mmol/L.</th>
<th>If urine ketones are moderate/large or blood ketones ≥0.6 mmol/L, or the pump is not working.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Give a correction bolus with the pump*.</td>
<td>• There may be a pump delivery problem or a significant illness developing. Give insulin injection by pen or syringe appropriate for the degree of hyperglycemia and ketonuria/ketonemia (as in Table 1 above or using the individual correction bolus*)—then problem solve any mechanical or catheter difficulties.</td>
</tr>
<tr>
<td>• Test the BG hourly.</td>
<td>• Continue to give bolus doses with a pen or syringe until the situation is under control.</td>
</tr>
<tr>
<td>• Drink extra low carbohydrate fluids.</td>
<td>• Replace the insulin in the pump, and the infusion set and cannula. Resume basal rate, using temporary basal rate of approximately +20% until BG is lowered.</td>
</tr>
<tr>
<td>• If BG is lower after 1 hour, recheck again in 1 to 2 hours and decide if another correction bolus dose is needed (use the unused bolus rule**).</td>
<td>• Monitor the BG hourly.</td>
</tr>
<tr>
<td>• If the BG is not lower after the first bolus proceed to give an injection with a syringe or pen (see column 2).</td>
<td>• Drink extra high carbohydrate fluids if the ketones are elevated and BG is low and extra low carbohydrate ‘diet’ fluids if BG is elevated with or without elevated ketones.</td>
</tr>
<tr>
<td></td>
<td>• If after 2 hours there is no improvement, liaise with diabetes pump team.</td>
</tr>
<tr>
<td></td>
<td>• If after 2 hours the BG is improved, use the unused bolus rule to decide if an additional bolus is needed**. Pump use can be resumed.</td>
</tr>
<tr>
<td></td>
<td>• If BG remains high, ketones persist, or nausea, vomiting or abdominal pain develop, contact the diabetes pump team or proceed to immediate hospital assessment.</td>
</tr>
</tbody>
</table>
Specific advice regarding sick day management on insulin pumps

- Patients on pumps use only rapid- or short-acting insulin and do not have any injected depot of long-acting insulin. Therefore, diabetic ketoacidosis can develop rapidly.
- In case of ketosis, extra insulin should always be given with a pen or syringe, not with the pump (as malfunction may be the cause of ketosis)