DKA, QUALITY, AND COSTS: How a Written Back-Up Plan Saves Money and Lives

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Early last summer, we, the staff of a pediatric endocrinology clinic, found ourselves earning extra steps on our pedometer apps by walking more frequently to the Pediatric Intensive Care Unit (PICU) from our Pediatric Endocrinology Clinic. We noticed an increase in these trips to see our pediatric patients with type 1 diabetes (T1D) admitted for diabetic ketoacidosis (DKA), defined as the presence of ketones in blood or urine and serum bicarbonate less than or equal to 15 mmol/L or pH less than 7.3.

At first the increase was subtle, and each individual case was managed with extra family education and a short stay. However, when we started compiling the PICU admission data, we realized several families were sharing the same reason for the tumble into DKA. It sounded something like this: "I guess the pump wasn't working and we didn't realize he/she was getting sick."

From January 2011 to June 2015, about 30% (n = 35) of our DKA admissions were caused by insulin pump malfunction or lack of action by patients and families in response to signs of interrupted insulin delivery.

Digging Into Our DKA Admissions

As providers and educators, we wanted to optimize DKA prevention for our patients and help minimize the need for costly comorbidity treatment with the potential for significant morbidity and mortality. An outpatient chart review showed provider-patient education on safe pumping practices was given and documented. However, the patient/family perceived a lack of knowledge about a pump back-up plan (as stated during the admission).

We asked patients what led up to their admission—how did it all start? Usually the patient responded that he or she noticed a rise in blood glucose (BG) and used the insulin pump correction factor bolus with no success. Here are the common steps on the journey to DKA:

- Step 1: BG is above 300 mg/dL. Use the pump to give a correction factor bolus.
- Step 2: Don't recheck the BG . . . or check and see a high BG and give another correction.
- Step 3: Don't check ketones. Don't do a site change.
- Step 4: Think it's a flu bug causing stomachache and vomiting. Go back to bed.
- Step 5: Can't keep fluids down and get dehydrated.
- Step 6: Don't call the clinic for advice.
- Step 7: Hopefully, go to the Emergency Room for care and admission to PICU.

A Commitment to Quality Improvement

As a result of these observations, a quality improvement project was born. We learned that most of our DKA admissions were related to new onset diabetes. These were patients we had not yet met, and we likely had little chance of preventing PICU admissions in these patients. However, 30% of our DKA admissions occurred in patients known to us, receiving insulin via insulin pump, and not correctly recognizing interruptions in insulin delivery and/or not taking appropriate actions to address the interruptions.

Knowing that DKA due to insulin pump malfunction can be prevented, the increasing expense of inpatient ICU care, and the risks to the child, our staff moved forward. The team included a certified diabetes educator (CDE), pediatric endocrinologists, pediatric endocrinology fellows, and nursing support staff.

A literature review did not identify any existing educational intervention data, but several articles pointed out this problem and suggested the need for intervention (see reference list). According to research led by Tieder, a cost analysis of inpatient admissions varied widely. Using mean data from multiple organizations, it was reasoned that if PICU admission days decreased, the cost avoidance could be over $3074 per admission. Also, eliminating additional follow-on costs in non-PICU rooms might add cost savings of over $2500 per admission.

The project started with pediatric patients 2 to 23 years of age in the outpatient clinic. All patients had T1D diagnosed at least 6 months prior to starting on the pump. After reviewing Bolderman's book on insulin pumps, we developed a written back-up plan to provide instructions on monitoring for signs of impending DKA, giving insulin by injection at specific doses, and trouble-shooting the pump (Figure 1).

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Diabetes Education Pump Back Up Plan Name:_____ DOB: _____

In the event of an insulin pump malfunction, please follow these instructions.

Pump Set Change Precautions: Always be aware of your Blood Glucose (BG) trends. When placing a new cannula, pick a time early in the day so you can monitor your BG. This will reassure you that the tubing and/or the insertion set is not kinked, leaking or blocked. If there was a problem with the flow of insulin, it may take several hours for the pump to alarm or it may not alarm at all. Check your BG at regular intervals in the hours after a change. Do not go to bed right after a set change. Watch your BG and/or CGM device throughout the day to make sure there are no trends caused by lack of insulin.

What Next?: If you notice BG readings above 300mg/dL twice in 2 hours after a bolus insulin (correction) and it continues to rise, suspect a pump set failure. Check ketones. Common causes are listed on side 2.

- When do we suspect pump set or pump failure?:
- You have symptoms of high BG. Examples: thirsty, frequent urination, tired, fruity breath, stomach aches.
- If the ketones are positive
- If high BG results continue even after correction

Act fast: Stop the pump, and give the Novolog correction factor by using your insulin pen or syringe/vial. Change the insulin pump cannula, tubing and resume your basal rate. Continue to check your BG at 30 minutes and then hourly until you are sure the infusion set is working properly and the BG results stay under 300mg/dL.

- Pump Back Up Plan: In case you are not certain the pump or tubing is working correctly, use this plan.
- Contact the insulin pump company representative to troubleshoot the problems. (Help numbers are on the back of the pump device)
- Stop the pump and disconnect the tubing and insertion set.
- If you will be off the pump for more than 1-2 hours without a basal rate, you must correct with Novolog or switch to a long acting insulin plan.
- Option 1: Correct using Novolog pen or syringe/vial with the insulin sensitivity factor (correction) every 3 hours. Use Novolog injections for your carbohydrate ratio with meals.
- Option 2: Use long-acting insulin plan (Lantus) after pump stops. **Your Dose:**_____ units Lantus once per day. Use Novolog injections for your correction factor and carb coverage at meals.
- When using Lantus, don't restart your usual pump basal rate on that day. This will cause low BG. Ask us for help transitioning back to the pump when ready.
- Be careful about high or low BG results during these changes in insulin therapy. Recheck ketones. Follow the sick day ketone plan and increase drinking of un-sweetened fluids. Carry fast-acting carb choices like glucose tabs.
- Contact the Diabetes Educator or the Pediatric Endocrine Doctor On-Call
- Ask about updating your insulin back up plan at every routine visit. Check your Lantus expiration dates and keep refills refrigerated. Replace an opened vial/pen every 28 days.

Staff Signature:_____ **Date:**_____

Patient/Parent Signature:_____

Diabetes Education Contact Information:

Figure 1. Diabetes education back-up plan. *(continues)*

Download this resource to use in your practice at diabeteseducator.org/AIPresources.

Pump Back Up Plan Side Two

Common Causes of Insulin Pump Malfunction:

- Loose connections
- Kinked or clogged cannula
- Air bubbles in tubing. Tubing that was not correctly primed.
- Cracked tubing
- Dislodged infusion set or cannula came out of skin
- Ineffective infusion site. Scarred skin or lipohypertrophy (fatty scars under the skin won't absorb well).
- Site irritation or infection
- Empty insulin reservoir
- Expired insulin or insulin that went bad due to heat or freezing
- Incorrect bolus doses or settings
- Missed bolus doses (check pump memory)
- Incorrect basal rate settings
- Pump was left in suspend mode for more than 2 hours
- Old batteries
- Pump malfunction (specific pump company technician can troubleshoot if replacement is needed)

Reference: Boldermann, Karen. "Putting Your Patients on the Pump". 2nd Ed. 2013.

Consider purchasing: Chase, Peter, MD & Laurel Messer, RN. "Understanding Insulin Pumps & Continuous Glucose Monitors". Children's Diabetes Foundation at Denver, CO.

Keep track of your current Novolog settings. Write in Pencil. Take a picture.

Dosing	**Time Segments**	**Units**	**Target BG**

Carb Ratios:

Correction Factors:

Documents enclosed are subject to the Privacy Act of 1974. Contents shall not be disclosed, discussed or shared with individuals unless they have a direct need-to-know in the performance of their official duties.

Figure 1. Diabetes education back-up plan.

The intervention included a pretest that analyzed the knowledge base of insulin pump patients or parents/guardians, an intervention in the form of the written insulin pump back-up plan, and a posttest at a follow-up visit (Figure 2). Individualized counseling was provided with the written plan, and it was documented in the medical record.

These standardized steps were followed when teaching DKA prevention.

- Step 1: Write it down. Prepare an insulin pump back-up plan when well. Take a smartphone picture of the plan to use anywhere.
- Step 2: If BG is >300 mg/dL, check urine or blood ketones.
- Step 3: Use correction factor, drink water, set alarm to recheck BG in 1 to 2 hours. Follow the written plan.
- Step 4: If highs continue, have any symptoms, or positive ketones, then dose insulin with a needle (pen or syringe) and change the pump site.
- Step 5: Report findings from Steps 2 through 4. Keep communicating with the health care team. Repeat.

Reducing Admissions With Back-Up Plans

After implementing written insulin pump back-up plans in June 2015, a decrease in inpatient admissions and an increase in the knowledge of

Insulin Pump Back-Up Plan Questions

Purpose: If the insulin pump fails or needs to be stopped, please tell us about your back up plan.

1. Do you have a written insulin pump back up plan?

   Yes / No

2. What is your back up basal insulin dose (usually Lantus insulin)?

   ____ *units*

3. Since starting on the pump, have you been in the hospital for DKA (Diabetic Ketoacidosis)?

   Yes / No

4. If the pump stopped, how confident are you knowing how much injectable insulin to give? Circle one:

   Very Confident *Confident* *Somewhat Confident* *Little Confident* *Not Confident*

Figure 2. Pre/posttest

Download this resource to use in your practice at diabeteseducator.org/AIPresources.

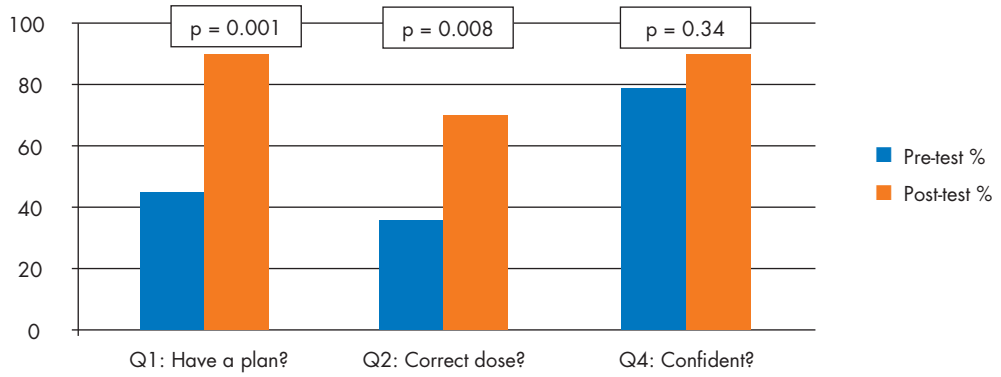

Figure 3. Pre/posttest comparison.

DKA prevention was observed. Admission data show only 1 DKA admission related to pump use since the project implementation. This patient, however, had not received the intervention. Including the nonintervention admission, there was a 75% reduction in admissions for pump-related DKA.

A total of 42 pretests and 30 posttests were completed and analyzed during the 6-month data gathering timeframe. Patients recalling having an insulin pump back-up plan increased from 43% to 90% at the follow-up visit (P = .001), and correctly listing the proper back-up long-acting insulin dosage increased from 37% to 70% (P = .008) (Figure 3).

As part of the quality improvement project, ongoing suggestions and feedback were utilized to evaluate the outcomes. Patient and professional feedback of the insulin pump back-up plan has been positive. Families are glad for the defined action plan. The health care system is taking note of the quality and financial benefits. Cost avoidance as compared to the previous 6 months would be estimated at $12 296 based on 4 fewer admissions to the PICU (not including non-PICU bed days).

Conclusion

While the staff may not be accumulating so many steps on pedometer apps now, they are pleased with the ability to catch knowledge deficits and prevent admissions. After successful use of a written plan and educational intervention as a quality improvement project, the information and tools will be shared in hopes of improving the outcomes of all T1D children. ■

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The views expressed in this article are those of the authors and do not reflect the official policy of the Department of the Army, Department of the Navy, Department of the Air Force, Department of Defense, or U.S. Government.

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