PEER REVIEWED

Diabetic ketoacidosis

Key elements of a good sick day care plan

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Diabetic ketoacidosis can be a life-threatening emergency. A sick day plan is vital in preventing and managing this condition.

Key points

- **Diabetic ketoacidosis is a potentially life-threatening emergency.**
- **The aims of a sick day plan are early recognition of impending ketosis, early initiation of treatment with hydration and insulin, and regular monitoring of blood glucose.**
- **Glucose replacement may be required alongside insulin therapy.**

Diabetic ketoacidosis (DKA) is a state of relative or absolute insulin deficiency leading to ketonaemia, acidaemia and, usually, hyperglycaemia. DKA is a potentially life-threatening emergency, the risk of which may be up to 10% per year per patient with type 1 diabetes.[1] Common precipitants include missed or insufficient insulin doses, new-onset type 1 diabetes and the increased physiological stress of acute illness.

The variable and often marked effect of acute illness on a patient's blood glucose levels has lead to the recommendation that those at risk of DKA develop a 'sick day plan'. Depending on the circumstances, hyperglycaemia and ketone formation can occur rapidly, possibly within hours. The aim of the sick day plan is:

- early recognition of impending ketosis
- initiation of treatment (i.e. hydration and insulin)
- regular monitoring of blood glucose levels to either prevent DKA or facilitate early medical intervention to avoid more severe illness.

Sick day education should ideally occur shortly after the diagnosis of diabetes has been made and requires regular review. This process should include the development of a written action plan and home sick day kit. Where appropriate, important support providers (such as schools and some workplaces) should be included in the education and preparation process.

Why is the sick day important?

There is no universal definition of a 'sick day' for the purposes of diabetic management. The adverse effects of acute illness on glucose levels are well recognised and may result in the requirement for more or less insulin depending on the context.

Acute infection and fever increase levels of counter-regulatory hormones including glucagon, cortisol, catecholamines and growth hormone, resulting in a metabolic shift to gluconeogenesis and lipolysis, which causes hyperglycaemia, accumulation of ketone bodies and subsequent acidosis. Continued, and often additional, insulin is necessary to suppress ketone and acid accumulation.

On the other hand, illness causing anorexia, vomiting or malabsorption will result in reduced carbohydrate delivery to the bloodstream. The unwell patient with diabetes can therefore walk a tightrope whereby the dose of insulin required to suppress ketogenesis may result in hypoglycaemia due to inadequate nutrition. As a result, carbohydrate supplementation is sometimes also required in the prevention of DKA.

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Preparation for the sick day

Education and preparedness are essential to implement a sick day action plan. Important supplies and information that should be maintained at home include:[2]

- a written copy of the sick day action plan and the contact details of the diabetic care team
- appropriate sick day foods and hydration supplies (including carbohydrate-containing fluids such as juice or sports drinks)
- sufficient supplies for monitoring finger prick glucose and ketone levels
- additional insulin supplies and an emergency glucagon kit.

Key principles of sick day care

Frequent glucose and ketone monitoring

Blood glucose levels should be monitored every two hours and more frequently if necessary (if there is hypoglycaemia, marked hyperglycaemia [>15 mmol/L] or significant ketone levels). Overnight checking of blood glucose levels should not be neglected.

Ketone levels should also be checked every two to four hours, especially if blood glucose levels are more than 15 mmol/L or in the presence of significant illness. Ketone levels can be quantitated more accurately with capillary (finger prick) testing and, if available, may be preferable to urine ketone measurements. There is some evidence that using capillary ketone measurements to guide early management reduces the need for emergency department presentation and decreases the severity of DKA by facilitating early intervention. Capillary ketone measurements may also be more useful in the dehydrated person with reduced urine output.[3]

Do not stop insulin

Insulin is an essential component of sick day management and increased doses are often necessary. Under no circumstances should insulin be ceased entirely, because even in the fasting state insulin is required to suppress ketogenesis.

A common error made by those struggling with anorexia or vomiting in acute illness is to reduce or withhold insulin to avoid hypoglycaemia. In these circumstances, it is more appropriate to increase carbohydrate intake (in the form of carbohydrate-containing fluids, etc) to allow continued or additional insulin use. In the context of vomiting, carbohydrate-containing fluids should be given and insulin administered to correct glucose levels to more than 8 mmol/L. Note that if insulin is given before the carbohydrate then hypoglycaemia can occur after vomiting.

The erratic nature of blood glucose levels in patients with acute illness can make appropriate insulin dosing challenging. It may be prudent to relax glycaemic targets somewhat (e.g. 6 to 10 mmol/L) to avoid hypoglycaemia related to excessive insulin correction.

Blood glucose levels more than 15 mmol/L and/or capillary ketone levels more than 1.5 mmol/L (equivalent to moderate to high urine ketone levels) require additional boluses of short-acting insulin. In general, 10 to 20% of an individual's total daily insulin dose should be given immediately, rather than waiting for the next meal-time dose. Glucose and ketone levels should then be monitored hourly. Moderate hyperglycaemia (blood glucose levels 8 to 15 mmol/L and/or capillary ketone levels 1 to 1.4 mmol/L [low to moderate urine ketone levels]) may require additional boluses of 5 to 10% of the total daily insulin dose with review every two hours. Oral hydration should be encouraged (as below).

Normal blood glucose (4 to 8 mmol/L) and/or capillary ketone levels less than 1.0 mmol/L (negative to trace urine ketone levels) can be managed with increased fluid intake without necessarily requiring additional insulin.

More detailed advice regarding insulin and fluid management with respect to glucose and ketone measurements is available in the clinical care guidelines.[4]

Hydration

The unwell patient with diabetes is prone to dehydration for several reasons, including the following:

- ketosis will significantly contribute to nausea and vomiting; any vomiting in a patient with diabetes should be considered a sign of insufficient insulin therapy until proven otherwise
- hyperglycaemia due to inadequate insulin dosing will result in an osmotic diuresis, aggravating fluid loss
- the underlying illness may cause additional fluid loss if vomiting, diarrhoea or fever occur.

Given the nature of these losses, fluid replacement should be osmotically appropriate, containing both salt and water. Depending on the glucose level, carbohydrate-containing fluids may be appropriate to both avoid hypoglycaemia and improve water absorption via the gut.

Parents of children with diabetes are advised to monitor urine output as well as fluid input, because this will give clues to their hydration status and the adequacy of rehydration.

In some patients it is inevitable that oral replacement of losses will be insufficient due to the underlying illness or the advanced state of DKA. Therefore, patients with persistent vomiting or diarrhoea and ongoing weight loss are advised to present early to an emergency department for assessment and intravenous hydration.

Managing the underlying illness

Assessment and treatment of any underlying illness is necessary and symptoms need to be carefully distinguished from those of hyperglycaemia and ketosis. It is important that investigation and treatment of associated issues do not delay or impede attention to the above principles.

Special circumstance: insulin pumps

Patients using insulin pumps for the management of diabetes are unique because they use only short or rapid-acting insulin in a constant infusion. Therefore, any interruption to this infusion renders the patient rapidly insulin deficient and DKA can occur within only a few hours.

Any unexpected increases in finger prick glucose levels in these patients should warrant assessment of the pump and tubing for any

abnormality affecting insulin delivery. The infusion set should also be changed to ensure the absence of any fault.

Insulin pump users should have ready access to alternative insulin preparations (e.g. disposable insulin pens) and a written action plan. In the event of pump failure, the pump then can be temporarily abandoned and the patient can immediately commence appropriate treatment with subcutaneous insulin injections.

Early medical assistance

Emergency medical care may be necessary if the patient's condition deteriorates or fails to respond to the above measures. This may occur in the following circumstances:[2]

- finger prick ketone levels persistently more than 1.5 mmol/L despite supplemental insulin
- persistently raised blood glucose levels despite supplemental insulin, or the inability to maintain blood glucose levels of more than 3.5 mmol/L
- neurological changes, such as confusion, seizures or altered conscious state
- persistent, uncontrollable vomiting
- inability to take oral fluids
- reductions in weight or urine output, or other signs suggestive of dehydration
- in young children
- associated disability or illness resulting in complex patient care
- family members unable or uncomfortable providing care at home.

Conclusion

DKA is a medical emergency that can be avoided or tempered by early intervention. A comprehensive sick day plan is the cornerstone of DKA prevention. **ET**

References

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