review of the nutritional and exercise guidelines to prevent hypoglycemia are beyond the scope of this update focused on acute management; however, prevention of hypoglycemia should be the priority in the education and management of type 1 diabetes. Recommendations for prevention of hypoglycemia with exercise can be found in an existing clinical practice guideline (see Physical Activity and Diabetes chapter [guidelines.diabetes.ca]).

For acute management of mild to moderate hypoglycemia, also referred to as level 1 and 2 hypoglycemia, required treatment with oral rapidly absorbed carbohydrate varies in amount based on the child's weight and/or mode of therapy (Table 3).

In children and adolescents with severe hypoglycemia, also referred to as level 3, which results in altered level of consciousness and impaired oral/enteral glucose intake, glucagon is the standard of care. In conscious individuals aged 4 years and older, intranasal glucagon is as effective as subcutaneous glucagon to resolve hypoglycemia [105]. Caregivers report that intranasal glucagon is easier to use and to teach than injectable glucagon [106]. Intranasal glucagon has not been studied in children under age 4 years, but may be the only alternative if injectable glucagon is unavailable, since availability is limited in Canada (https://jdrf.ca/changes-to-glucagon-availability-in-canada/). In conscious children aged 6 years and older, subcutaneous dasiglucagon, which does not require reconstitution, may be used to treat hypoglycemia; however, at the time of this publication, it is not available in Canada [107].

DKA

This section provides an update on clinical practice recommendations for management of DKA since 2018 (see Hyperglycemic Emergencies in Adults chapter and Type 1 Diabetes in Children and Adolescents chapter [guidelines.diabetes.ca]). Recommendations focus only on areas where new evidence has emerged.

DKA is an emergency caused by relative insulin deficiency and increased counterregulatory hormones. This results in hyperglycemia, decreased extracellular fluid volume, and fatty acid oxidation resulting in a metabolic acidosis. Clinically, this can present as a combination of the signs and symptoms of hyperglycemia, acidosis, and any underlying precipitant. DKA can be graded in terms of severity depending on the mental status and degree of metabolic changes. There are no absolute clinical criteria, but a commonly applied classification is presented in Table 4.

Table 4
Severity of diabetic ketoacidosis

Capillary blood gas	Mild	Moderate	Severe
pH	7.25–7.35	7–7.24	<7
Bicarbonate (mmol/L)	15–18	10–15	<10
Anion gap (mmol/L)	>10	>12	>12–15
Mental status	Alert	Alert/drowsy	Stupor/coma

Intravenous fluids

Since 2018, a number of studies in the pediatric population have assessed the question of optimal intravenous fluid composition and administration to improve outcomes, in particular with respect to speed of resolution of DKA and risks of cerebral edema.

Five studies have compared a balanced crystalloid (Plasmalyte, Ringer's Lactate, Hartman's Solution) to 0.9% normal saline [108–112]. In mild to moderate DKA, these studies have found no difference in measured outcomes, including length of stay and cerebral edema. In addition, multiple clinical trials have assessed hypotonic compared against isotonic fluid administration in DKA. The largest trial, PECARN DKA FLUID, randomized 1,389 episodes of pediatric DKA in a 2-by-2 design of either fast (20 ml/kg bolus) or slow (10 ml/kg bolus) administration of either hypotonic or isotonic fluid [113]. Ultimately, there was no clear benefit of any particular strategy in terms of the primary outcome of cerebral injury or the secondary outcomes of neurocognitive function and recovery. While this was an apparent null finding, the trial has led to a change in clinical practice as fluid resuscitation in children has traditionally been conservative due to concerns around cerebral edema. Nevertheless, this study did not capture sufficient episodes of severe DKA to make a definitive fluid recommendation in this specific subset of individuals. Useful algorithms and order sets for management of pediatric DKA, which align with the present recommendations, have been published by TREKK (Translating Emergency Knowledge for Kids) (link to https://trekk.ca/topic/dka).

Subcutaneous insulin

Resolution of DKA requires administration of insulin to stop lipolysis and ketoacid production. Intravenous insulin is rapid in onset of action, can be titrated frequently or discontinued quickly, and has long been the standard of care for DKA management. However, this means of insulin delivery requires intensive supervision and monitoring, often in a critical care setting, as it carries a risk of hypokalemia and hypoglycemia. Subcutaneous insulin does not require intensive care admission, and may be preferential in some presentations and clinical settings.

In pediatrics, 1 randomized controlled trial has evaluated the safety and efficacy of using subcutaneous insulin (0.15 U/kg every 2 hours) instead of intravenous insulin infusion for mild or moderate DKA [114]. In this trial, frequent subcutaneous insulin injection resulted in lower cumulative insulin dose, lower length of stay in moderate DKA, and there was no increase in adverse event rates.

In 2016, a Cochrane Review of 5 randomized controlled trials in adults, including 201 episodes of DKA, showed no increase in harm when using subcutaneous insulin [115]. However, because the included studies were small, and judged to be of low quality, no recommendation was made in the 2018 Diabetes Canada guidelines. Since then, a large interventional cohort study involving 7,989 DKA hospitalizations showed a decrease in ICU length of stay, without increase in harm, with the use of a subcutaneous insulin protocol. Given the increased pressures on the health-care system, management of mild to moderate DKA with subcutaneous insulin is a reasonable option.

Limitations and future directions

This expert author group acknowledges that glycemic management of type 1 diabetes is influenced by factors beyond therapeutic options and choice of insulin delivery system. Daily life with type 1 diabetes requires careful navigation of strategies around nutrition, physical activity, and exercise. Previous Diabetes Canada guidelines have addressed prevention of hypoglycemia during exercise in adults but not in children. Nutrition also has been addressed in previous chapters. The approach to management of physical activity and nutrition in the setting of AID has changed considerably [116] since these guidelines have been published. Updated Canadian recommendations are needed for management of nutrition and exercise in type 1 diabetes but were outside the scope of this guideline. Given the mental toll and countless burdens associated with type 1 diabetes self-management, it is critical to routinely address mental health and the well-being of each individual and their family/caretakers. All of these elements should be carefully balanced while working collaboratively with people living with type 1 diabetes to optimize care and to help them achieve their individualized health goals.