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Early-Onset Type 1 Diabetes: Family-Centered Insulin Initiation and Early Technology Adoption in a Preschool Child

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Case Report
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Abstract

Background: Early-onset type 1 diabetes (T1D) in preschool children is associated with rapid metabolic decompensation and distinctive management challenges for caregivers. Contemporary pediatric guidelines emphasize prompt diagnosis, individualized insulin therapy, structured diabetes self-management education and support (DSMES), and early adoption of continuous glucose monitoring (CGM) with consideration of automated insulin delivery (AID) systems to improve safety and glycemic control.

Case Presentation: A previously healthy 4-year-old child presented with a two-week history of polyuria, polydipsia, nocturnal enuresis, fatigue, and 1.5 kg weight loss. Initial investigations demonstrated a random glucose of 398 mg/dL (22 mmol/L), HbA1c of 11.2%, urine ketones ++, bicarbonate 20 mEq/L, and positive glutamic acid decarboxylase (GAD) and IA-2 antibodies. Management included isotonic fluid therapy, initiation of a pediatric basal-bolus insulin regimen, structured family-centered DSMES, and early CGM implementation. The family adopted CGM on hospital day two and transitioned to hybrid closed-loop AID therapy by week eight.

Outcomes: At three months, HbA1c improved to 7.1%, with CGM time-in-range (70-180 mg/dL) of approximately 68% and hypoglycemia below 70 mg/dL occurring 2.1% of the time. At six months, HbA1c further improved to 6.8% without severe hypoglycemia or diabetic ketoacidosis (DKA).

Conclusion: Early diagnosis, family-centered DSMES, and rapid implementation of diabetes technology can significantly improve glycemic outcomes and reduce acute complications in young children with T1D. These findings support current recommendations advocating early integration of CGM and AID technologies in pediatric diabetes care (1-4, 8-12).

Keywords: Diabetes; Technology; Management; Childhood; Diagnosis

Abbreviations

T1D: Type 1 Diabetes; DSMES: Diabetes Self-management Education and Support; AID: Automated Insulin Delivery; CGM: Continuous Glucose Monitoring; GAD: Glutamic Acid Decarboxylase; DKA: Diabetic Ketoacidosis.

Introduction

Type 1 diabetes is the most common chronic endocrine disorder of childhood and remains a significant contributor to pediatric morbidity worldwide. Young children are particularly vulnerable to delayed diagnosis because

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symptoms may be subtle, poorly communicated, or mistaken for common childhood illnesses. Consequently, preschool-aged children have a heightened risk of presenting with ketosis or diabetic ketoacidosis (DKA), a potentially life-threatening condition requiring prompt recognition and treatment [1-3].

The American Diabetes Association and the International Society for Pediatric and Adolescent Diabetes recommend age-specific management strategies emphasizing early insulin initiation, caregiver education, continuous glucose monitoring, and multidisciplinary follow-up to improve long-term outcomes [1,4-6] Advances in CGM and hybrid closed-loop AID systems have transformed pediatric diabetes management. These technologies have demonstrated improvements in glycemic control, increased time-in-range, reduced hypoglycemia, and decreased caregiver burden, even in very young children [7-12]. This report describes the diagnosis, treatment, and successful implementation of early diabetes technology in a preschool child with newly diagnosed T1D [1-6].

Case Presentation

A previously healthy 4-year-old child presented with a 14-day history of polyuria, polydipsia, nocturnal enuresis, fatigue, decreased appetite, and an unintentional 1.5-kg weight loss. There was no family history of diabetes mellitus or autoimmune disease. Physical examination revealed mild dehydration, dry oral mucosa, and tachycardia (120 beats/min) without altered mental status or Kussmaul respirations. Laboratory studies demonstrated a random plasma glucose of 398 mg/dL (22 mmol/L), HbA1c of 11.2%, glucosuria, ketonuria, and elevated β-hydroxybutyrate. Serum bicarbonate measured 20 mEq/L. Autoimmune testing was positive for GAD and IA-2 antibodies, confirming autoimmune type 1 diabetes. The patient met criteria for ketosis without severe DKA because mental status remained normal and serum bicarbonate was above 18 mEq/L [2,13,14].

Therapeutic Interventions

Acute Management

The patient received a 20 mL/kg isotonic saline bolus followed by maintenance and deficit fluid replacement according to contemporary pediatric DKA prevention protocols [2,13,14]. A basal-bolus insulin regimen was initiated with a total daily dose of approximately 0.5 U/kg/day [2,13,14].

Family-Centered Diabetes Education

Comprehensive DSMES was initiated immediately following diagnosis. Educational topics included insulin administration, blood glucose monitoring, carbohydrate counting, recognition and treatment of hypoglycemia, ketone testing, and sick-day management. Written educational materials and emergency action plans were provided. Caregivers received prescriptions for glucagon and ketone testing supplies. Structured sick-day education has been shown to reduce preventable diabetes-related emergencies and improve home management confidence [3,15,16].

Early Technology Adoption

CGM was implemented on hospital day two. Caregivers received training regarding sensor placement, trend-arrow interpretation, alarm management, and communication with school personnel. Studies involving young children have demonstrated that CGM reduces hypoglycemia, improves glycemic metrics, and decreases caregiver burden [7,8,12]. The patient was discharged after 48 hours with scheduled endocrinology follow-up and telehealth support as needed [9-11].

Follow-Up and Outcomes

At the two-week follow-up visit, caregivers demonstrated proficiency in insulin administration and carbohydrate counting. Minor nocturnal hypoglycemia episodes were successfully managed through a 10% reduction in basal insulin dosage.

At eight weeks, following a shared decision-making discussion with the family, the patient transitioned to a hybrid closed-loop AID system. Clinical trials in children younger than six years have demonstrated significant improvements in time-in-range and overall glycemic control with these systems [9,10].

At three months, HbA1c decreased from 11.2% to 7.1%, with a CGM-derived time-in-range of approximately 68% and time below 70 mg/dL limited to 2.1%. At six months, HbA1c further improved to 6.8%, with no episodes of severe hypoglycemia or diabetic ketoacidosis. These outcomes align closely with contemporary pediatric glycemic targets recommended by ISPAD [6].

Discussion

Early recognition remains critical in preschool children because progression from initial symptoms to DKA may occur rapidly. Delays in diagnosis continue to account for substantial diabetes-related morbidity in children. Prompt glucose testing in symptomatic children remains an essential strategy for preventing metabolic decompensation [1,2,3,6].

A fundamental aspect of successful management is comprehensive family-centered education. Young children are entirely dependent on caregivers for diabetes management, making DSMES a cornerstone of treatment. Education

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regarding ketone monitoring, insulin administration, hypoglycemia treatment, and sick-day protocols significantly improve safety and confidence while reducing avoidable emergency department visits [15,16].

Diabetes technology played a central role in this patient's favourable outcome. Consistent CGM use in children younger than eight years has been associated with improved glycemic control, reduced hypoglycemia, and improved quality of life for caregivers [7,8,12]. Furthermore, hybrid closed-loop AID systems have demonstrated significant reductions in HbA1c and increased time-in-range, with benefits sustained for at least 18 months in young children [9,10].

Insulin pump therapy is also associated with lower rates of severe hypoglycemia and diabetic ketoacidosis compared with multiple daily injections; however, device malfunction remains an important risk factor requiring backup injection plans and ongoing caregiver education [11,17,18]. In toddlers and preschool children with extremely low insulin requirements, pharmacy-supervised diluted insulin formulations may further improve dosing precision and facilitate successful AID use [19,20].

Current ISPAD recommendations advocate HbA1c goals of ≤6.5% when advanced diabetes technologies can be used safely and effectively and ≤7.0% when such technologies are unavailable or unsuitable [6]. The patient's six-month HbA1c of 6.8% reflects successful implementation of evidence-based therapy and technology-assisted diabetes management.

Conclusion

This case highlights the importance of prompt recognition and treatment of type 1 diabetes in preschool-aged children. Early initiation of insulin therapy, structured family-centered DSMES, and rapid integration of CGM and hybrid closed-loop technologies resulted in substantial improvement in glycemic control and prevention of acute diabetes-related complications. The patient's HbA1c improved from 11.2% at diagnosis to 6.8% within six months, without severe hypoglycemia or diabetic ketoacidosis. These outcomes support growing evidence demonstrating that early adoption of diabetes technology, combined with ongoing caregiver education and multidisciplinary support, can significantly improve both clinical outcomes and quality of life in young children with type 1 diabetes [1,4-12].

Learning Points

- Maintain a high index of suspicion for type 1 diabetes in preschool-aged children presenting with polyuria, polydipsia, weight loss, or nocturnal enuresis.
- Utilize pediatric-specific protocols emphasizing isotonic fluids and careful insulin titration to reduce DKA-related complications.
- Provide comprehensive family-centered DSMES at diagnosis, including written sick-day and ketone management plans.
- Initiate CGM as early as feasible and consider AID systems to improve time-in-range and reduce hypoglycemia.
- Consider diluted insulin preparations in selected young children with very low insulin requirements.

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