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# Inadvertent Use of Long-Acting Insulin with Automated Insulin Delivery System in a Child with Newly Diagnosed Stage 3 Type 1 Diabetes: Case Report

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**Case Report**

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# Abstract

### Background

Type 1 diabetes (T1D) is an autoimmune disease characterized by immune-mediated destruction of pancreatic β-cells, resulting in an insulin deficiency and hyperglycaemia. Intensive insulin therapy delivered through multiple daily injections or continuous subcutaneous insulin infusion (CSII) remains the cornerstone of treatment. Automated insulin delivery (AID) systems are increasingly used to optimize glycaemic control. Rapid-acting insulin analogues are recommended for continuous subcutaneous insulin infusion (CSII); however, treatment errors may occur, particularly during the early phase of T1D management, when caregivers are still developing experience in diabetes care.

### Case presentation

We report the case of a 3.5-year-old child with newly diagnosed stage 3 T1D who initiated therapy using an AID system (mylife Ypso pump with CamAPS and Dexcom G6). Fifty-nine days after discharge, it was discovered that the child had been unintentionally receiving insulin glargine instead of lispro from the first home infusion set change due to caregiver confusion and continuation of prescriptions by the primary care physician.

Retrospective analysis of two-week AID reports representing the earliest available datasets after recognition of the error demonstrated stable glycaemic control during the period of glargine use (time in range >80%) without diabetic ketoacidosis or severe hypoglycaemia. Limited hypoglycaemic episodes were observed only during the first days captured in the available reports. After reintroduction of lispro, insulin requirements decreased by approximately 40% while maintaining stable glycaemic control.

### Conclusions

Unintentional use of insulin glargine in an AID system did not result in severe metabolic deterioration in this case, possibly due to partial remission and algorithm-driven insulin adjustments. This case highlights the importance of caregiver education, verification of insulin type, and multidisciplinary awareness to prevent medication errors in paediatric T1D management. It also illustrates how automated insulin delivery systems may partially compensate for unexpected pharmacokinetic deviations, highlighting both the resilience and safety considerations of AID therapy. To our knowledge, this is the first reported case of this type of insulin administration error involving inadvertent use of an incorrect insulin preparation.


# Background

Type 1 diabetes (T1D) is an autoimmune disease caused by the T-cell mediated destruction of insulin-producing pancreatic β-cells, resulting in insulin deficiency and hyperglycaemia. Clinical disease typically manifests after approximately 70% of β-cells have been destroyed [1]. However, advances in screening now allow identification of individuals in the early stages of T1D, prior to the onset of clinical symptoms.

Consequently, T1D is currently classified into stages: stage 1, defined by the presence of ≥ 2 islet autoantibodies with normoglycaemia; stage 2, characterized by ≥ 2 autoantibodies with dysglycaemia; and stage 3, defined by ≥ 2 autoantibodies with hyperglycaemia, with or without clinical symptoms. Stage 3 is further subdivided into 3a and 3b depending on the presence of symptoms [1, 2]. Although approximately 50% of newly diagnosed stage 3 T1D cases occur in adults [3], many individuals are diagnosed in childhood, and it is still the leading type of diabetes in the paediatrics population [4]. When children are diagnosed with T1D, their caregivers face the important task of learning about the disease and its treatment in order to provide effective day-to-day care and support their children's long-term health and well-being. A considerable challenge arises particularly at the beginning of treatment, when insulin doses and insulin-to-carbohydrate ratios must be frequently adjusted according to the child's age and stage of development, which often places an additional burden on caregivers. Importantly, shortly after the initiation of insulin therapy, partial remission - commonly referred to as the "honeymoon phase" - may occur. This phase is associated with a temporary recovery of residual β-cell function and a transient increase in endogenous insulin secretion, resulting in reduced exogenous insulin requirements during the early period of T1D treatment [4].

Nowadays, technology plays an important role in T1D management and helps in reducing the burden related to the disease and constant therapeutic decision-making. As of now, there is no cure for individuals living with T1D, and the only effective treatment is intensive insulin therapy. This can be done through multiple daily insulin injections (MDI) or continuous subcutaneous insulin infusion (CSII) using the insulin pump [5]. With time, automated insulin delivery (AID) systems have become more accessible, and the number of their users is constantly increasing [6]. According to the recommendations both regular human insulin (RHI) and rapid acting insulin analogue (RAIAs) can be used in CSII with the second being the preferred choice [7].

In the case study presented below, a child with recent onset symptomatic stage 3 T1D was unintentionally administered long lasting insulin analogue in AID pump (CamAPS). The objective is to present how unintentional use of glargine in AID influenced the glycaemic control in a child with recent onset of stage 3 T1D.

## Case presentation

A 3.5-year-old child with newly diagnosed stage 3 T1D (C-peptide 0.241 ng/ml at diagnosis) initiated insulin therapy (lispro) with the AID system using mylife Ypso pump with CamAPS and Dexcom G6. When discharged from the hospital, the AID target was set to 104 mg/dl and daily insulin requirement was equal to 0.75 IU/kg/day. Following control visits presented stable glycaemic control, however the problems with frequent air bubbles formation in the infusion sets and relatively high insulin demand were noticed (with the average daily insulin dose equal to 0.70 IU/kg/day in the two-weeks report preceding detection of glargine misuse).

After 59 days, during one of the control visits at the Diabetes Clinic, it turned out that just after being discharged from the hospital (from the first self-directed set infusion change at home), the child was being administered glargine insulin instead of lispro*.

*Glargine insulin was prescribed as a long-lasting insulin to be used in an insulin pen in the case of an insulin pump failure. This is a standard practice following the established guidelines for post-hospital discharge care. All relevant information has been properly documented in written form and communicated to the caregivers before the discharge. It turned out that the parents had mistaken the insulin and received further prescriptions from their primary care physician who was not updated on the child's ongoing T1D therapeutic regimen. The sequence of the events discussed above is summarized in the timeline presented in Fig. 1.

Images Fig. 1 – Timeline of clinical events.

# Differential diagnosis, investigations and treatment:

At this point the child was readmitted to the hospital in order to reintroduce lispro insulin and provide re-education for the parents. Physical examination did not reveal any abnormalities, the patient appeared well.

Statistical reports, each covering a two-week period, were generated from the AID - CamAPS application to assess potential changes in glycaemic control. Due to the reporting functionality of the CamAPS FX system, detailed retrospective reports from the very first days following the insulin mix-up were not available. The reports presented below therefore represent the earliest available datasets obtained after the error was recognized.

## Results (Outcome and follow-up)

The first report corresponds to the initial hospital stay during which lispro insulin was administered. This is followed by two reports from the period of unintentional glargine insulin use. The subsequent three reports reflect the reintroduction of lispro insulin and the resulting glycaemic control. The data was presented in the Table 1 below.

Table 1
Data presenting glycaemic control generated from the AID - CamAPS application.

| **CamAPS report's period** | **First stay at the hospital with lispro (100 IU/ml) used.** | **Unintentional Glargine (100 IU/ml) use.** | | **Reintroduction of Lispro (100 IU/ml) after detecting Glargine misuse.** | | |
|---|---|---|---|---|---|---|
| | **14.06–18.06.** **(mean of 4 days)** | **6.07.-19.07** | **2.08–15.08** | **15.08–28.08.** | **28.09.-11.10.** | **8.11.-21.11.** |
| Mean Glucose Value (mg/dL) | 140 | 117 | 134 | 114 | 131 | 136 |
| Time in Range TIR (%) | 84 | 90 | 87 | 95 | 90 | 86 |
| Time below Range TBR (%) | 2 | 4 | 0 | 1 | 1 | 0 |
| Time above Range TAR (%) | 14 | 6 | 13 | 4 | 9 | 14 |
| Coefficient of variation (%) | 28 | 30 | 28 | 29 | 28 | 27 |
| Average daily insulin dose (IU/kg/day) | 0.75 | 0.50 | 0.70 | 0.42 | 0.40 | 0.30 |
| Basal:bolus ratio (%) | 59:41 | 48:52 | 54:46 | 53:47 | 60:40 | 52:48 |
| Glucose management indicator (GMI; %) | 6.7 | 6.1 | 6.5 | 6.0 | 6.4 | 6.6 |
| Target in AID (mg/dl) | 104 | 104 | 104 | 110 | 110 | 110 |

Apart from a decrease in average daily insulin dose (IU/kg/day) by around 40% after lispro reintroduction, the analysed parameters indicated stable glycaemic control (TIR > 80%) in both periods. The percentage of Auto Mode use remained high (98% and 99%, respectively), with Auto Mode exits occurring only due to CGM data errors related to sensor replacement.

Because the TBR (%) value alone may not fully reflect the potential hypoglycaemic effect of insulin misuse, hypoglycaemic events were additionally analysed in both reports covering the periods of glargine misuse.

During the first analysed period (06.07–19.07), the child experienced hypoglycaemic episodes within the first three consecutive days, occurring during nighttime and early morning hours. These events did not recur later in the observation period. The total time < 54 mg/dL during the two-week period was < 0.2%.

In the second report covering the period 02.08–15.08, four hypoglycaemic events were observed within two consecutive days. Two of these episodes were postprandial and occurred at similar times of the day.

No severe hypoglycaemia requiring additional medical consultation or hospitalization was recorded.

## Discussion and conclusions

The inadvertent use of an incorrect insulin type did not lead to the marked deterioration in glycaemic control or the development of diabetic ketoacidosis (DKA). This may be attributed to a low insulin requirement - suggestive of residual endogenous insulin secretion during the partial remission phase (mean TDD < 0.5 IU/kg/day) - as well as the compensatory effect of an automated insulin delivery (AID) system.

Insulin glargine was the first basal insulin analogue developed to provide prolonged and stable insulin activity [8]. After subcutaneous administration, it forms precipitates in the tissue from which insulin is gradually released, resulting in a prolonged action lasting up to 24 hours with an onset of approximately 2–4 hours.

In this case, glargine U-100 was delivered via continuous subcutaneous insulin infusion (CSII) in low doses. This mode of administration may not have intensified its hypoglycemic effect but may instead have contributed to a more stable pharmacodynamic profile. However, no scientific reports are currently available that fully explain the behavior of glargine U-100 under these conditions.

Commercial automated insulin delivery (AID) algorithms are designed and validated for rapid-acting insulin analogues (e.g., insulin aspart, lispro, or faster aspart). These systems estimate insulin-on-board (IOB) using predefined pharmacodynamic models that assume an onset of action of approximately 10–20 minutes, peak activity at 60–90 minutes, and a duration of action of about 4–6 hours.

In this case, insulin glargine was inadvertently placed in the pump reservoir. Because glargine has markedly different pharmacokinetic properties, including delayed onset (approximately 2–4 hours) and prolonged, relatively peakless activity exceeding 20 hours, the algorithm continued to calculate IOB based on rapid-acting insulin assumptions while the delivered insulin exhibited long-acting kinetics.

This pharmacokinetic mismatch has several theoretical implications. Most importantly, the algorithm would likely underestimate residual insulin activity due to the assumed shorter duration of action. Repeated microboluses delivered by the AID system could therefore lead to cumulative insulin exposure and increase the risk of delayed hypoglycemia once glargine activity becomes apparent.

Several factors may have mitigated adverse effects in this case. First, glargine forms subcutaneous microprecipitates that release insulin slowly and continuously, producing a relatively flat pharmacodynamic profile. When delivered in small pump pulses, this mechanism likely resulted in gradual absorption rather than discrete activity peaks. Second, the closed-loop system continuously adjusted insulin delivery using real-time continuous glucose monitoring (rtCGM), allowing dynamic responses to glucose trends. Third, the patient had newly diagnosed symptomatic stage 3 T1D with partial remission, characterized by low insulin requirements and residual endogenous insulin secretion, which likely reduced the risk of severe hypoglycemia.

Because the algorithm continued to estimate IOB using rapid-acting insulin parameters, the calculated values did not reflect the prolonged biological activity of glargine, meaning the system operated under incorrect pharmacokinetic assumptions.

In the 3.5-year-old patient, reintroduction of insulin lispro resulted in decreased insulin requirements and resolution of air bubble formation in the infusion sets. Preserved glycaemic stability may have been partly related to the remission phase.

The period following a diagnosis of type 1 diabetes (T1D) is particularly challenging for both patients and caregivers. In this case, diagnosis related stress, confusion between insulin preparations, and communication gaps contributing to an incorrect insulin prescription likely played a role in the insulin administration error. The circumstances surrounding this event highlight the potential for medication errors during the early stages of T1D management and underscore the importance of multi-step verification during medication prescribing, including careful assessment of the patient's current treatment regimen. To reduce the risk of similar errors, caregivers should receive clear education on insulin preparations, including visual verification and double-checking procedures during reservoir and infusion set changes. Teach-back methods and supervised practical training may help ensure correct understanding of insulin administration. In addition, effective communication between caregivers, primary healthcare professionals, diabetes specialists, and pharmacists may facilitate earlier identification and prevention of treatment-related errors.

Advanced diabetes technologies can help identify treatment-related problems and support optimization of glycaemic control. However, their effective use depends on appropriate user engagement and understanding.

This report has several limitations. Most importantly, pump reports from the first days following the insulin mix-up were unavailable because of limitations in the CamAPS FX reporting system. Consequently, the analysed data represent the earliest available records obtained after the error was recognized.

When asked about the patient perspective, the caregivers reported that, due to the overwhelming emotions associated with the diagnosis and the stressful period surrounding it, they were not always able to fully remember all the information necessary for their child's treatment, despite having received

comprehensive training in the hospital. The second hospital visit provided reassurance and increased their confidence and sense of competence in caring for their child.

To our knowledge, this is the first reported case of this type of insulin administration error involving inadvertent use of an incorrect insulin preparation.

## Abbreviations

AID
automated insulin delivery
CGM
continuous glucose monitoring
CSII
continuous subcutaneous insulin infusion
DKA
diabetic ketoacidosis
GMI
glucose management indicator
IOB
insulin on board
MDI
multiple daily injections
RAIAs
rapid–acting insulin analogues
RHI
regular human insulin
rtCGM
real–time continuous glucose monitoring
T1D
type 1 diabetes
TAR
time above range
TBR
time below range
TIR
time in range

## Declarations

**Clinical trial number:** not applicable

**Ethics approval and consent to participate:** Not applicable

**Consent for publication:** Written informed consent was obtained from the parents of a child to publish this report in accordance with the journal's patient consent policy.
**Data availability statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

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# Figures

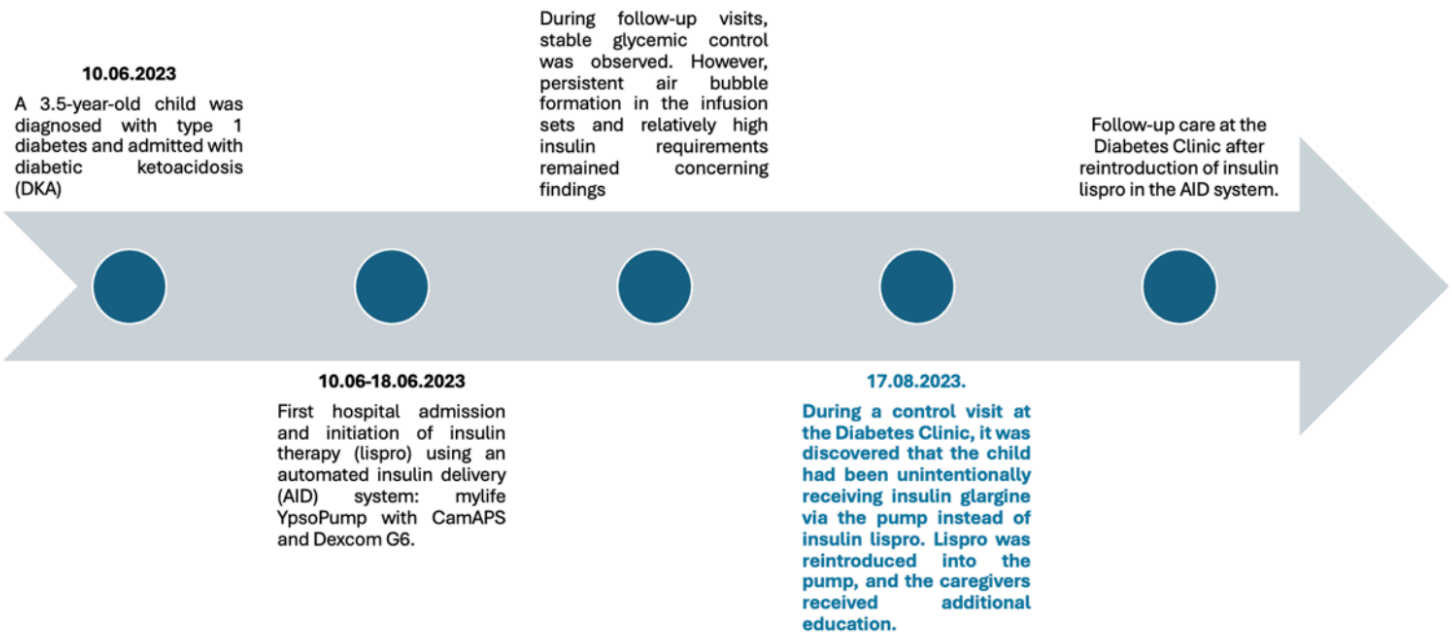



**Figure 1**

Timeline of clinical events.