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Case Report

Crossing of Autoimmunity and Metabolic Dysfunction: A Case of Double Diabetes in an Algerian Adolescent

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ABSTRACT

Background: The rising prevalence of childhood obesity and sedentary lifestyles has blurred the traditional distinction between type 1 and type 2 diabetes. *Double diabetes* represents the coexistence of autoimmune β-cell destruction and insulin resistance, posing diagnostic and therapeutic challenges, particularly in adolescents.

Case presentation: We report the case of a 17-year-old obese female with a three-year history of type 1 diabetes who developed marked insulin resistance and metabolic syndrome features. Despite high insulin requirements (1.6 U/kg/day), glycemic control remained poor (HbA1c 12.8%). Clinical examination revealed obesity (BMI 32.4 kg/m²) and acanthosis nigricans. Laboratory evaluation showed preserved C-peptide secretion, dyslipidemia, elevated leptin and homocysteine levels, and positivity for anti-GAD65 and islet cell antibodies, supporting the diagnosis of double diabetes.

Management and Outcomes: A combined therapeutic strategy including optimization of basal-bolus insulin therapy, adjunctive metformin, structured nutritional intervention, and regular physical activity was implemented. Six months later, and at the stage of her transition, HbA1c decreased to 7.8%, body weight was reduced by 8 kg, daily insulin requirements decreased by 35%, and lipid parameters improved significantly.

Conclusion: This case highlights the importance of early recognition of double diabetes in youth and demonstrates that integrated metabolic and autoimmune-targeted management can significantly improve glycemic control and cardiometabolic risk.

Keywords: Double Diabetes; Adolescents; Obesity; Insulin Resistance; Autoimmunity; Algeria

Introduction

Double diabetes represents a complex metabolic condition characterized by overlapping of type 1 and type 2 diabetes. This entity emerges when insulin resistant individuals with type 1 diabetes develop characteristics of type 2 diabetes, or conversely, when patients with type 2 diabetes demonstrate markers of type 1 diabetes [1]. Traditional diabetes classifications prove insufficient in managing double diabetes which necessitates therapeutic approaches addressing both insulin deficiency therapy and insulin resistance. Accumulating evidence establishes double diabetes as a distinct clinical entity, as affected individuals often exhibit both autoimmune and metabolic features [2]. The increasing prevalence of obesity, coupled with sedentary lifestyle patterns, has complicated the clinical differentiation between type 1 and type 2 [3]. Clinicians increasingly recognize double diabetes in patients with type 1 diabetic who develop features typical of type 2 diabetes, including obesity, hypertension, and dyslipidemia [4]. Epidemiological studies demonstrate that double diabetes is becoming increasingly prevalent among children with type 1 diabetes who experience weight gain in and metabolic syndrome [5]. The global increase in childhood obesity suggests that the natural history of diabetes may be evolving. Evidence indicates that insulin resistance in 25%-30% of patients with type 1 diabetes, predisposing them to cardiovascular complications typically associated with type 2 diabetes patients [6].

The diagnostic entity of double diabetes poses substantial clinical challenges, creating specific barriers to optimal disease management. Timely recognition is essential, as therapeutic strategies effective for type 1 or 2 diabetes alone may prove effective inadequate in these patients. Delayed or inaccurate diagnosis results in suboptimal treatment outcomes and increases the risk of developing nephropathy, retinopathy and cardiovascular disease [7]. Patients with double diabetes face major difficulties achieving glycemic targets, necessitating comprehensive multidisciplinary care that integrates lifestyle with insulin therapy and insulin sensitizers [8]. The worldwide burden of diabetes mandates improved understanding of double diabetes to enhance patient outcomes and optimize healthcare resource allocation.

This article presents the case of a 17-year-old female diagnosed with double diabetes, highlighting diagnostic challenges, therapeutic strategies, and the importance of sustainable lifestyle modifications for optimal long-term outcomes.

Case Report

A 17-year-old female presented to the clinic for evaluation of poorly controlled, refractory type 1 diabetes, diagnosed three years earlier following an episode of diabetic ketoacidosis requiring intensive care admission. She reported persistent fatigue, polyuria, and polydipsia, with occasional ketonuria, accompanied by unintentional weight gain of approximately 16 kg over the preceding two years.

Her body mass index (BMI) was 32.4 kg/m², consistent with class I obesity. Family history was notable for type 2 diabetes in a parent and an aunt. The patient reported a sedentary lifestyle, characterized by high consumption of processed foods, sugar-sweetened beverages, and refined carbohydrates.

On physical examination, blood pressure was within normal limits (110/78 mmHg). Dermatological examination revealed mild, velvety, hyperpigmented plaques in the axillary regions, consistent with acanthosis nigricans, suggestive of underlying insulin resistance. Although both office and ambulatory blood pressure measurements were normal, continued longitudinal monitoring was recommended given the patient's metabolic risk profile and evidence of early vascular changes.

Urinalysis demonstrated 3+ ketonuria, and capillary blood glucose monitoring revealed persistently elevated levels with marked intra- and inter-day variability. The patient was receiving a total daily insulin dose of 1.6 units/kg/day.

Laboratory investigations showed a fasting plasma glucose level of 12.9 mmol/L and an HbA1c of 12.8%, indicating poor glycemic control. Fasting C-peptide was measured at 2.5 ng/mL in the presence of significant hyperglycemia (14.3 mmol/L). This finding indicates preserved endogenous insulin secretion, which is notable in the context of long-standing type 1 diabetes and suggests residual β-cell function.

Lipid profile revealed total cholesterol of 2.43 mmol/L, LDL cholesterol 1.75 mmol/L, HDL cholesterol 0.68 mmol/L, and triglycerides 1.48 mmol/L.

Assessment of insulin resistance using HOMA-IR was not feasible due to ongoing exogenous insulin therapy. Therefore, alternative surrogate markers were considered. Serum leptin was elevated at 37.7 ng/mL, while adiponectin was 8.63 µg/mL, resulting in a reduced adiponectin-to-leptin ratio, indicative of adipose tissue dysfunction and insulin resistance.

The estimated glucose disposal rate (eGDR), calculated using waist circumference (102 cm), HbA1c, and hypertension status, was approximately 5.0 mg/kg/min. Values below 6 mg/kg/min are generally

associated with significant insulin resistance and increased cardiometabolic risk.

Additional investigations revealed markedly elevated homocysteine levels (49.19 µmol/L). Apolipoprotein A1 (1.38 g/L) and apolipoprotein B (0.72 g/L) were also measured. Autoimmune evaluation confirmed the presence of anti-GAD65 and islet cell antibodies. Microalbuminuria was within normal limits.

Carotid Doppler ultrasound demonstrated a carotid intima-media thickness (CIMT) of 0.6 mm, corresponding to the 75th percentile for age and sex, suggestive of early subclinical vascular involvement.

Psychological assessment revealed significant diabetes-related distress, with a Problem Areas in Diabetes (PAID) score of 68/100 and a Diabetes Distress Scale (DDS) score of 3.2/6, which may adversely affect treatment adherence, self-management, and glycemic control.

Table 1: clinical and laboratory results

Test	Result	Reference range
Fasting blood glucose	12.9 mmol/L	4.4–7.2 mmol/L
HbA1c	12.8%	< 5.7 %
Fasting C-peptide	2.5 ng/mL	0.5–2.0 ng/mL
GAD-65 Antibodies	Positive	Negative
Islet cell antibodies (ICA)	Positive	Negative
Homocysteine	49.19 µmol/L	5–15µmol/L
Leptin	37.7 ng/mL	Girl in post-puberty : **5 – 25 ng/mL**
Adiponectin	8.63 µg/mL	4–30µg/mL
Apolipoprotein A1	1.38 g/L	1.1–1.8g/L
Apolipoprotein B	0.72 g/L	0.6–1.2g/L
BMI	32.4 kg/m²	18.5–24.9 kg/m² (normal)
Total cholesterol	2.43 mmol/L	< 5.2 mmol/L
LDL cholesterol	1.75 mmol/L	< 3.0 mmol/L
HDL cholesterol	0.68 mmol/L	**> 1.0** mmol/L
Triglycerides	1.48 mmol/L	< 1.7 mmol/L
Microalbuminuria	Normal	< 30 mg/24 h
Ketonuria	3+	Negative
Daily insulin dose	1.6 IU/kg/day	—

Diagnosis and treatment strategies

Double diabetes represents the convergence of type 1 and type 2 diabetes characteristics, forming a complex condition with both autoimmune and metabolic components. Diagnosis was established based on clinical presentation, biochemical profile and risk factors. Detection of pancreatic autoantibodies confirmed type 1 diabetes, while obesity, acanthosis nigricans, preserved C-peptide, and marked elevations in homocysteine and leptin indicated insulin resistance characteristic of type 2 diabetes. The coexistence of these features distinguished her condition from either diabetes type alone and necessitated a dual therapeutic approach. Understanding these overlapping disease mechanisms is essential for early intervention, treatment optimization, and improved metabolic outcomes in patients with double diabetes.

Management began with a basal-bolus insulin regimen to achieve rapid glycemic control. Basal insulin (glargine 0.3 units/kg/day) was supplemented with pre-prandial boluses of rapid-acting insulin (lispro), adjusted according to carbohydrate intake and self-monitoring of blood glucose. This regimen targeted fasting glucose between 4.4 and 7.2 mmol/L and postprandial blood glucose levels below 9.99 mmol/L. To address significant insulin resistance, metformin therapy was initiated at 500 mg daily and gradually titrated to 1000 mg twice daily to minimize gastrointestinal side effects. Metformin was intended to improve hepatic and peripheral insulin sensitivity, reduce total insulin requirements, and facilitate weight loss. Lifestyle modification formed the cornerstone of long-term management. Individualized nutritional counselling focused on achieving a moderate calorie deficit, targeting10 to 15% weight loss within the first year. The patient underwent a **structured nutritional intervention** tailored to address obesity, insulin resistance, and poor glycemic control. The plan emphasized **balanced macronutrient distribution** with approximately **45–50% carbohydrates, 20–25% protein, and 25–30% fat**, focusing on complex carbohydrates with a low glycemic index, high fiber intake, and healthy unsaturated fats. Total **daily caloric intake** was individualized based on age, activity level, and weight management goals, targeting gradual weight reduction of 0.5–1 kg per week. Specific dietary frameworks incorporated elements of the **Mediterranean-style diet**, emphasizing vegetables, legumes, whole grains, lean protein, and minimal consumption of sugar-sweetened beverages and processed foods. This structured approach was combined with education on portion control, meal timing, and carbohydrate counting to optimize glycemic control and support adherence.

Physical activity goals included at least 180 minutes weekly of moderate intensity aerobic exercise (brisk walking, swimming) and resistance training two to three times weekly to enhance muscle mass and metabolic flexibility. Cardiometabolic risk factors were addressed concurrently. She received a continuous glucose monitoring device (IcanI3), enabling real-time glucose tracking and informed adjustments to insulin dosing and dietary intake. Follow-up appointments were scheduled every three months to assess glycemic control, blood pressure, and adherence to lifestyle recommendations, while providing ongoing diabetes education, psychological support, and self-management training.

Follow-Up, Outcomes, and Transition

At the six-month follow-up, the patient demonstrated marked clinical and metabolic improvement. Glycemic control improved substantially, with HbA1c decreasing to 7.8%. Fasting glucose levels stabilized between 5.0 and 6.5 mmol/L, and postprandial excursions were significantly reduced.

She achieved a weight loss of 8 kg, resulting in a meaningful reduction in BMI and improvement in waist-to-hip ratio. Total daily insulin requirements decreased by approximately 35%, reflecting improved insulin sensitivity. The lipid profile also improved, with LDL cholesterol reduced to 1.20 mmol/L and triglycerides to 1.1 mmol/L.

In parallel, the patient reported improved quality of life, increased energy levels, and sustained adherence to dietary and physical activity recommendations. Enhanced treatment adherence and greater engagement in self-management were observed, supported by improved psychological well-being.

Given these favorable outcomes, the patient was considered ready for transition to adult diabetes care, demonstrating increased autonomy, therapeutic adherence, and adequate self-management skills.

A structured transition from pediatric to adult care is essential in adolescents with type 1 diabetes to ensure continuity of care and optimize long-term outcomes. The transition process should ideally follow a stepwise, multidisciplinary approach comprising four key phases:

1. **Preparation phase:** focusing on patient education, development of self-management competencies, and comprehensive metabolic and psychosocial assessment.
2. **Transition planning phase:** involving identification of the adult care team, development of an individualized care plan, and integration of psychological support.
3. **Transfer phase (ages 18–19):** ideally conducted through joint pediatric–adult clinic visits to ensure continuity, with emphasis on insulin regimen adjustment, recognition and management of hypo- and hyperglycemia, and sick-day rules.
4. **Post-transition follow-up:** including early and regular adult clinic visits to monitor glycemic control, cardiovascular risk factors, and adherence, alongside ongoing education and psychosocial support.

Long-term management should emphasize patient empowerment, sustained lifestyle modification,

and regular screening for microvascular and macrovascular complications.

This structured, multidisciplinary approach is particularly critical in adolescents with combined autoimmune diabetes and insulin resistance, where metabolic complexity and psychological burden may significantly impact long-term outcomes.

Table 2: Follow-Up Results At 6months

Parameter	Baseline	6-month follow-up	Change
HbA1c	12.8%	7.8%	↓ 5.0%
Fasting blood glucose	12.9 mmol/L	5.0–6.5 mmol/L	Improved
Weight loss	—	−8 kg	—
BMI	32.4 kg/m²	Reduced	Improved
Daily insulin requirements	1.6 IU/kg/day	↓ 35%	−35%
LDL cholesterol	1.75 mmol/L	1.20 mmol/L	↓ 0.55 mmol/L
Triglycerides	1.48 mmol/L	1.1 mmol/L	↓ 0.38 mmol/L
Energy level	Fatigue	Increased	Improved
Physical activity	Sedentary	Regular	Improved

Discussion

This case describes a 17-year-old female with established type 1 diabetes who subsequently developed clinical and biochemical features of insulin resistance, consistent with a phenotype commonly referred to as double diabetes. The coexistence of autoimmune β-cell dysfunction and metabolic disturbances reflects the evolving phenotype of diabetes in youth, driven in part by the global rise in obesity.

Double diabetes is increasingly recognized in pediatric populations and is typically characterized by the presence of pancreatic autoantibodies alongside features of insulin resistance, including obesity, acanthosis nigricans (Figure 1), dyslipidemia, and increased insulin requirements. In the present case, positivity for anti-GAD65 and islet cell antibodies confirmed autoimmune diabetes, while obesity, elevated leptin levels, and high insulin requirements supported the presence of significant insulin resistance. The persistence of measurable C-peptide levels three years after diagnosis further suggests residual endogenous insulin secretion, a feature that may persist longer in patients with double diabetes than in classical type 1 diabetes, thereby complicating diagnostic classification [9–11].

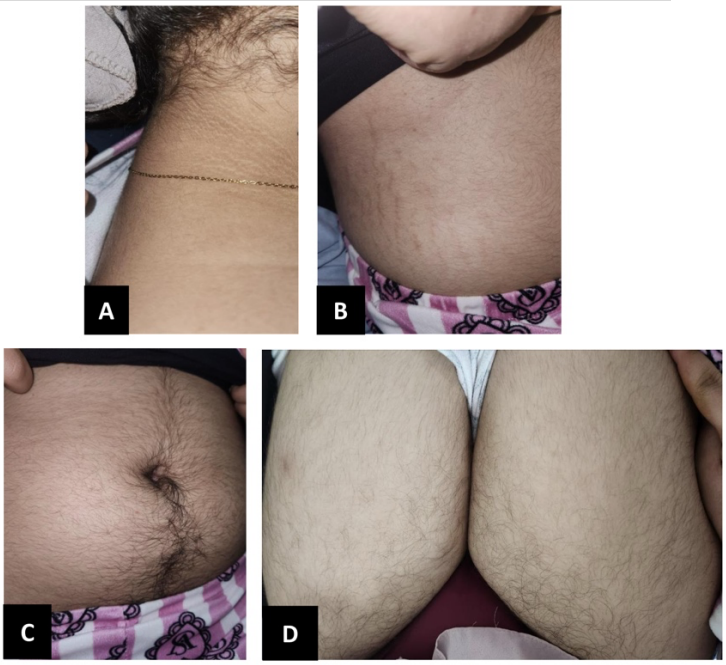

Figure 1. Clinical photographs demonstrating cutaneous manifestations of insulin resistance in a 15-year-old female with double diabetes. (A) Posterior neck showing marked acanthosis nigricans with velvety hyperpigmentation and skin thickening. (B) Lateral abdominal wall showing skin texture changes. (C) Periumbilical region & (D) Upper thighs with hair growth patterns.

The metabolic profile observed in this patient highlights the increased cardiovascular risk associated with this condition. In particular, the markedly elevated

homocysteine level is noteworthy. Hyperhomocysteinemia is a well-established independent risk factor for endothelial dysfunction and cardiovascular disease and may further amplify long-term complications. In the context of double diabetes, where cardiovascular risk arises from the interplay between autoimmune and metabolic abnormalities, elevated homocysteine may represent an additional and potentially modifiable risk factor [12,13].

Carotid intima-media thickness (CIMT) is a validated marker of subclinical atherosclerosis. Although the value observed in this patient (75th percentile) remains within reported reference ranges for age, its association with obesity, insulin resistance, dyslipidemia, and hyperhomocysteinemia suggests early vascular involvement. These findings support the need for close longitudinal monitoring to assess the progression of cardiovascular risk.

Despite normal vitamin B12 and folate levels, the marked elevation in homocysteine suggests a multifactorial etiology, potentially involving insulin resistance, metabolic dysregulation, or underlying genetic determinants. This observation underscores the importance of comprehensive cardiovascular risk assessment and individualized management in patients with double diabetes.

Management of double diabetes requires an integrated approach targeting both insulin deficiency and insulin resistance. In this case, optimization of insulin therapy combined with metformin and structured lifestyle interventions resulted in substantial clinical improvement, including reductions in HbA1c, insulin requirements, body weight, and lipid parameters. These findings are consistent with previous studies demonstrating that metformin may reduce insulin dose and improve metabolic outcomes in adolescents with type 1 diabetes and insulin resistance [14,15].

Metformin was selected as the first-line insulin-sensitizing agent due to its established safety profile, accessibility, and evidence base in pediatric populations. Emerging therapies, including GLP-1 receptor agonists and SGLT2 inhibitors, offer promising additional benefits such as weight reduction, improved insulin sensitivity, and potential cardiovascular protection. However, their use in adolescents remains limited by regulatory constraints, cost, and safety concerns, including gastrointestinal intolerance, risk of diabetic ketoacidosis, and genitourinary infections. These considerations highlight the importance of individualized, context-specific therapeutic strategies and the need for further research in this population.

Lifestyle modification remains a cornerstone of management. Regular physical activity and dietary optimization play a central role in improving insulin sensitivity and reducing cardiometabolic risk. The magnitude of improvement observed in this case likely reflects early recognition, multidisciplinary care, strong treatment adherence, and the use of continuous glucose monitoring to optimize insulin titration.

Several limitations should be acknowledged. Quantitative assessment of insulin resistance was limited by ongoing exogenous insulin therapy, and genetic testing was not performed. In addition, the relatively short duration of follow-up precludes assessment of the long-term sustainability of metabolic improvements and complication risk.

Finally, the transition from pediatric to adult care represents a critical and vulnerable period for adolescents with double diabetes. This process requires coordinated, multidisciplinary support involving pediatricians, endocrinologists, nutritionists, and mental health professionals. Psychosocial challenges, loss of parental support, and increased self-management responsibilities may compromise adherence and increase the risk of acute complications such as diabetic ketoacidosis and severe hypoglycemia.

In Algeria, structured transition programs for adolescents with diabetes remain limited. The lack of dedicated adolescent care units and standardized transition protocols may contribute to suboptimal glycemic control and increased psychological burden. In this context, our patient benefited from anticipatory guidance, structured education, family involvement, and psychological support, which facilitated engagement and preparedness for transition.

Table 3: Diagnostic Criteria for Dual Diabetes in this Case

Feature	Type 1 Diabetes	Type 2 Diabetes	Present in Patient
Age at T1D diagnosis	12 years	—	✓
DKA at presentation	Yes	Rare	✓
Autoantibodies (GAD-65, ICA)	Positive	Negative	✓ Positive
C-peptide	Low/undetectable	Normal/elevated	✓ 2.5 ng/mL (preserved)

Feature	Type 1 Diabetes	Type 2 Diabetes	Present in Patient
Obesity (BMI ≥30 kg/m²)	Uncommon	Common	✓ 32.4 kg/m²
Acanthosis nigricans	Absent	Present	✓ Present
Family history of T2D	Uncommon	Common	✓ Parent and aunt
Insulin resistance markers	Absent	Present	✓ Elevated homocysteine, leptin
Dyslipidemia	Mild/absent	Common	✓ Elevated TC, LDL, TG
Sedentary lifestyle	Variable	Common	✓ Yes
High processed food intake	Variable	Common	✓ Yes

Conclusion

Double diabetes is a complex clinical condition that combines metabolic and immunological traits, necessitating increased diagnostic attention. Early detection using autoimmune markers, C-peptide levels, and insulin resistance testing is critical to reduce the risk of complications. To enhance long-term metabolic results, optimal management depends on a mix of insulin therapy, insulin-sensitizing medications, and long-term lifestyle modifications. Emerging technologies such as continuous glucose monitoring, AI-driven clinical decision support, and precision medicine, as well as targeted immunotherapies and genetic profiling, show promise for personalized treatment, improved early detection, and better long-term metabolic outcomes in patients with double diabetes.

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