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A 5-dimension patient education program targeting type 2 diabetes remission

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Abstract – Introduction: Type 2 diabetes (T2D) reversal has been demonstrated in patients undergoing bariatric surgery or low caloric diets. **Objective:** To investigate the effects of therapeutic patient education alone on T2D reversal in early diagnosed patients. **Methods:** Seventeen T2D patients underwent a one-week therapeutic education program, followed by 12 months of 1 hour sessions every month, targeting diabetes reversal. This reversal was determined using the DiaRem score which integrates glycated hemoglobin levels and antidiabetic drug treatment. Patient's conceptions, perceptions and motivation were assessed using a 5-dimensional psychopedagogic score. **Results:** After 1 year, the mean HbA_{1C} fell from 7.2% (± 1.9) to 6.2% (± 0.8) ($p < 0.05$), antidiabetic drug doses decreased by 25% ($p < 0.05$), and the DiaRem score increased by 15% ($p < 0.01$), indicating a reversal of the disease, not correlated to weight loss. At the end of the study, 15 out of 17 patients had excellent glycemic control ($HbA_{1C} < 7.0\%$) and 4 patients had parameters compatible with partial diabetes remission. A significant improvement in glycemic control coupled with a lowering of antidiabetic drug treatment was observed. **Conclusions:** Following an initial therapeutic education program and regular consultation sessions thereafter, early diagnosed patients may reverse their type 2 diabetes.

Keywords: diabetes / therapeutic patient education / reversal / remission

Résumé – Une éducation thérapeutique en 5 dimensions pour la rémission du diabète de type 2. Introduction : La rémission du diabète de type 2 (DT2) a été observée suite à la chirurgie bariatrique ou à des régimes hypocaloriques. **Objectifs** : Étudier l'effet d'une éducation thérapeutique sur la réversibilité du DT2. **Méthodes** : Dix-sept patients DT2 ont bénéficié d'un programme d'éducation d'une semaine, suivi de rencontres mensuelles d'une heure, durant un an, avec pour objectif le recul du diabète. Cette réversibilité a été caractérisée par l'évolution d'un score (DiaRem) prenant en compte l'hémoglobine glyquée (HbA_{1C}) et le traitement antidiabétique. Conceptions, perceptions et motivation du patient ont été évaluées grâce à un score psychopédagogique en 5 dimensions. **Résultats** : Après un an, 15/17 patients atteignent un excellent contrôle glycémique ($HbA_{1C} < 7.0\,\%$). L'HbA_{1C} moyenne est passée de 7.2 % (± 1.9) à 6.2 % (± 0.8) ($p < 0.05$), les médicaments antidiabétiques ayant été simultanément diminués de 25 % ($p < 0.05$) en moyenne. Le score DiaRem a augmenté de 15 % ($p < 0.01$). Ces éléments témoignent d'un recul de la maladie qui n'est pas corrélée à la perte de poids. À un an, 4 patients se retrouvent avec des paramètres compatibles avec une rémission partielle du diabète. **Conclusions** : Des patients diabétiques de type 2 récents peuvent faire reculer leur maladie grâce à un programme d'éducation thérapeutique et un suivi régulier.

Mots clés : diabète / éducation thérapeutique du patient / réversibilité / rémission

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1 Introduction

Type 2 diabetes mellitus (T2D) can today be considered as a potentially reversible disease particularly in the first years after diagnosis [1–4]. Bariatric surgery has provided supporting evidence by demonstrating that a massive weight loss in patients resulted in a decrease of insulin resistance and an increase in insulin production in patients on oral antidiabetic drugs (ADDs) and even in some on insulin treatment prior to surgery [5–7]. The parameters found to be relevant when comparing cohorts of T2D patients before/after surgery include glycated hemoglobin, duration of diabetes, age, presence of insulin and other antidiabetic treatments, and, in certain studies, the presence of complications from diabetes [7–9].

Other improvements include hormonal changes, a sharp decrease in liver and pancreas ectopic fat content, a decrease in liver insulin resistance and hepatic glucose production [10,11]. This led to the controversial "metabolic by-pass surgery" for obese T2D patients with relatively low body mass index (BMI) ($< 35\,kg\,m^{-2}$) and even for non-obese T2D individuals [12,13].

The improved function may be explained by reduced beta-cell apoptosis combined with a regeneration process, also described as a "rebirth", of the beta cells [14–16]. These results prompted us to re-examine our usual conceptions about the evolution of T2D. A consensus statement from the American Diabetes Association (2009) proposed definitions for a partial, complete and prolonged remission or a cure of T2D [17].

All these findings from bariatric surgery in T2D patients opened new perspectives for diabetes remission also after nonsurgical intensive lifestyle interventions. We recall previous observations on how patient motivation, especially regarding weight loss and nutrition, could lead to T2D remission [18]. These earlier propositions are better understood now, especially after research groups recently promoted very low calorie diets to obese patients. Taylor *et al.*, in particular, have observed short-term glycemia normalization after two months caloric restriction of about 600 Kcal per day [15]. They measured a sharp decrease of fat content in the liver and pancreas and subsequent normalization of insulin secretion.

Parallel to all these experiments based on nutrition for weight loss, the 20th century saw great progress in the understanding of muscle metabolism. The "insulin resistance" concept led to a better prevention and treatment of metabolic syndrome by promoting weight loss but more interestingly by emphasizing the importance of physical reconditioning for T2D patients [19,20].

Several publications have recently shown that endurance as well as resistance training could lower insulin resistance and prevent or treat T2D [21–24]. The muscle is now recognized as a very rich endocrine organ with hundreds of myokines produced during physical activity or just after it, targeting the gut, brain, pancreas and numerous other organs [25].

One of the common challenges we face with T2D patients is how to enhance their motivation to learn about their disease and how to control their blood sugar by adopting healthier lifestyles together with the appropriate use of medical treatment. Several interventions have targeted one of several components of behavior change, such as physical activity [26]. However, we are not aware of other education programs explicitly aimed at T2D reversal by providing continuous motivational support combined with nutritional and physical activity education, and with a psychological approach to eating disorders and stress lowering for long lasting weight loss, apart from previous studies from our team [27]. The present study aims to assess the effectiveness of such a program over 1 year and to test the hypothesis that it could lead to a reversal of the disease in some recently diagnosed T2D patients.

2 Aim of the study

To evaluate T2D evolution following a 1-year patient education program explicitly targeting the disease remission by assessing glycemic control and drug treatment.

3 Study design

This was a prospective, non-comparative study.

3.1 Subjects and methods

Patients were referred either by their attending physicians or diabetologists and were recruited as they presented at the centre. The research protocol was accepted by the Cantonal Commission for Research Ethics (CCER) of the State of Geneva. All patients gave their written informed consent to participate.

3.1.1 Inclusion criteria

Male and female adults with recently diagnosed T2D (maximum of 7 years), treated with ADDs alone (non-insulin requiring).

3.1.2 Exclusion criteria

Patients with a diagnosis of T2D for over 7 years or requiring insulin therapy were excluded from the study. In addition, patients presenting micro-vascular complications, those subjected to bariatric surgery, patients with severe psychological problems or severe eating disorders were also excluded. No upper age limit was set and there were no upper or lower BMI limits or limitations to the type of antidiabetic treatment of patients (number and nature of molecules).

3.1.3 Methods

The protocol consisted of a 5-day outpatient hospital TPE program about T2D, its risks and how to manage their disease, including treatment. This program included individual sessions and group workshops. This was followed by 12 individual monthly sessions lasting 1 to 1.5 h, to continue patient education, understand their needs and stimulate motivation. This included biomedical and psychological aspects of the disease, as well as the need for physical activity and the development of nutrition skills.

During the monthly sessions, we informed the participants that their disease could be reversed if, after learning about their

Table 1. Description of the 5-day ambulatory education program.
Tableau 1. *Description du programme d'éducation ambulatoire de 5 jours.*

Session type	Duration	Number of sessions	Setting	Health educator
Patient expression	1h00	3	I/G	Nurse/MD/Psy./AT
Work on physical perceptions	0h30	1–2	I	Nurse/MD/Ped.
Measurement and regulation of glycemia	0h30	2–4	I	Nurse/Ped.
Practical physical activity	1h30	3–4	G	Nurse/Phy.
Diet workshop	1h30	2–3	G	Nurse/Diet.
Drugs and complications	1h00	1–2	I/G	MD/nurse
Conceptions about T2D	1h00	1–2	G	Ped.
Workshop on diabetes regulation	1h30	1–2	I/G	MD/nurse
Workshop on the philosophy of self-care	0h30	1–2	I	Psy./Ped./MD

Abbreviations: I: individual setting (1 patient – 1 to 2 health care educators), G: group setting (8 to 10 patients – 1 to 3 health care educators), MD: medical doctor, Ped.: pedagogist, Psy.: psychologist, Diet.: dietitian, Phy.: physiotherapist, AT: art therapist.

disease, they initiated lifestyle changes and adhered to their drug treatments, although we also informed them that there was no guarantee of success in terms of remission. This delicate part of the educational and motivational process was facilitated by a strong therapeutic alliance between caregivers and patients throughout the entire 12-month process.

The evaluations conducted pre- and post-TPE included the main biomedical parameters of diabetes, antidiabetic treatments and a psychopedagogic evaluation. Age, gender, duration of diabetes since diagnosis and BMI were also recorded at baseline.

3.1.4 Ambulatory TPE program on diabetes

The 5-day outpatient TPE program is offered to T2D patients at our hospital. The program consists of 10 to 12 group sessions, usually with 10 patients, as well as about 8 to 10 individual sessions, lasting from 0h30 to 1h30, distributed throughout the week. This program is often slightly modified during the week, depending on the evolution of the patient's needs as perceived by the health educators. The program included sessions about conceptions, body perceptions and the importance of learning how to treat diabetes. There were practical workshops on physical activity, nutrition, and the measurement and regulation of their glycaemia. Other knowledge and skills were also developed, including emotions related to the disease, interest in the use of different drug treatments and prevention of unbalanced diabetes complications (see Tab. 1). The caregivers involved were a multidisciplinary team of medical doctors, nurses, dieticians, psychologists, educators and art therapists [28].

3.1.5 Therapeutic patient education methodology

This was based on the combination of three broad areas of competence that was to be promoted at all times:

- the strongest possible therapeutic alliance between caregivers and patients;
- a pedagogic approach taking into account the 5 dimensions of the person to facilitate learning;
- the uptake by patients of the relevant knowledge and skills necessary to control, stabilize and improve the determinants of diabetes.

These elements were implemented in a systemic manner. They were not undertaken in a particular order, or independently of each other. The scheme was flexible, depending on the rhythm of the patient or the caregiver, and each step was repeated as often as necessary.

3.1.6 Therapeutic alliance

In order to strengthen the therapeutic alliance, both during the ambulatory TPE program and the monthly individual follow-up, experienced and trained caregivers adopted a non-judgmental approach offering attentive listening with an attempt to understand the patients' experience as closely as possible, focusing on authenticity and trust in order to progressively increase the quality of the relationship. There was a constant effort to value and enhance patient resources and successes, to encourage them and reinforce them positively. An example was to offer tests or exercises in which the patient could only succeed.

3.1.7 Patient learning in 5 dimensions

The general goal was to provide the patient with appropriate knowledge that would help them to improve their health. This implicated prior understanding of the patient's conception of his/her disease. Following semi-directed interviews, patients were attentively listened to and their questions were approached in depth in order to bring out the paradigms, organizing concepts of the patient's thought, their ways of reasoning and any contradictions.

Five dimensions of the patient were taken into account (see Ref. [29]):

- cognitive: patients received information in the form of explanations or metaphors and constructed or criticized their models of thought;
- affective: patients expressed their emotions, could feel the unconditional support to approach sensitive subjects;
- perceptive: patients worked on their body sensations, feelings, experienced the effect of a certain behavior or treatment;
- infra-cognitive: patients were challenged by the confrontation of contradictory information, interrogation of the intimate reasonings, the foundations of thought;

– meta-cognitive: patients were led to analyze their purpose, their sense of learning, their motivation for change.

This multidimensional approach to patient education has been extensively described elsewhere and is part of the daily care for all the hospital health care providers in our team [28–30].

3.1.8 Relevant subjects addressed on the determinants of T2D

The determinants of T2D explored with the patients included:

– lessons on known causes of T2D, affected organs, the meaning of laboratory results, drug action and long-term complications of unbalanced diabetes;
– workshops on nutrition, physical activity, emotional state with perceived stress, organization of life, problematic food behavior;
– individual identification of elements that could promote the remission of T2D, for each patient. For example, the promotion of certain types of physical activity more particularly adapted to a specific patient.

3.1.9 Monthly outpatient follow-up

The monthly individual TPE sessions lasted about 1 to 1.5 hours. Educational activities were tailored, depending on the learning needs perceived by the caregiver. The goal was to support learning and motivation for behavioral changes and to continue the personalized teaching on the determinants of T2D as mentioned above. During these sessions, we reinforced the idea of diabetes remission.

3.2 Evaluation

3.2.1 Assessment parameters

The main values recorded before and after the patient education program were weight, BMI, glycated hemoglobin (HbA_{1C}), and antidiabetic drug treatment.

3.2.2 DiaRem score

We chose the DiaRem Score, described by Still *et al.*, to characterize T2D before and after our education program [7]. This score was originally used to help better predict the probability of diabetes remission expected after bariatric surgery. The score includes parameters such as age, HbA_{1C}, intake of oral ADDs and the use of insulin. This score was slightly adapted to integrate the number of antidiabetic molecules, and presented from 0 (lowest probability) to 100 (highest probability), for a better motivation and understanding by the patient.

Adapted DiaRem score (0–100): probability of remission (in %) = $100 - 0.45 \cdot (\text{age} - 40) - 9 \cdot (HbA_{1C} - 6) - 9 \cdot$ (number of antidiabetic molecules excluding insulin) $- 55 \cdot$ (1 if patient on insulin treatment, 0 if not) (adapted from Ref. [7]).

3.2.3 Psychopedagogic and psychological evaluation

To assess the different psychopedagogical dimensions potentially linked with patient's motivation and behavior changes, we developed a methodology and scale, briefly described here and in Table 2 [28].

During the patient interview, these key issues were evaluated and graded by the health care provider on a 1–4 scale (1 = weakest, 4 = strongest), and related to 5 main dimensions interacting with the learning process (cognitive, emotional, perceptive, infra-cognitive and meta-cognitive).

Three other issues were questioned in the same way: stress management, motivation to learn, relationship between the health care provider and the patient (Tab. 2). The validated anxiety-depression questionnaire (HAD) was also given to the patient.

3.3 Statistical analysis

A sample-size determination was performed before the start of the study. A power calculation was undertaken based on the postulated change in HbA_{1C}. Eleven participants would be required to demonstrate an absolute fall of 0.8% in HbA_{1C} (assuming a SD of 0.5 with 95% power at the 5% significance level).

The results are expressed as means ± standard deviation. Correlation coefficients were calculated by considering the valid conditions (continuous variables, independent observations). Statistical differences between variables were calculated using the *t*-test for paired groups. Multivariate correlation analysis and all other statistical calculations were made using Excel© Software, Microsoft™, USA.

4 Results

The study was proposed to 24 adult patients of which 22 accepted to participate, were included into the study and followed for 12 months. Seventeen patients completed the protocol including the final evaluation, whereas 5 patients dropped-out of the study for personal reasons (Fig. 1).

The baseline characteristics of the 22 patients are presented in Table 3. At inclusion, 17 out of the 22 patients had BMI > 30 kg m^{-2}, 4 were overweight and one had a BMI considered normal (24.3 kg m^{-2}). Two patients had decompensated diabetes which required transient insulin therapy on arrival in the ambulatory TPE program, treatment that was expected to stop once the blood sugar stabilized (within days).

The 22 patients received basic therapeutic education at the hospital but only 17 patients continued the program until the final 12-month evaluation period, achieving an average of 8.3 (± 3.0) scheduled individual sessions.

Weight decreased on average by 3.4 kg (± 5.9) and BMI by 1.2 kg m^{-2} (± 2.0). Glycated hemoglobin fell from an average of 7.2% (± 1.9) to 6.2% (± 0.8) ($p < 0.05$) in 12 months (Tab. 4). At the end of the study, only two patients had a value greater than 7% (7.3% and 8.5%, respectively) compared with 6 having values greater than 7% at inclusion.

Given the evolution of the clinical parameters of the patients (weight, physical activity carried out, modifications in the diet) and particularly the drop in HbA_{1c}, physicians spontaneously lowered their diabetes medication with the mean intake of ADDs decreasing from 2.0 (± 1.0) to 1.5 (± 1.0) ($p < 0.05$) (Tab. 4).

Table 2. Indicators for patient assessment in the 5 main psychopedagogical dimensions and other issues related with the patient's involvement and motivation (intermediate indicators 2 and 3 are not documented here).
Tableau 2. *Indicateurs pour l'évaluation des patients dans les 5 principales dimensions psychopédagogiques ainsi que les paramètres liés à l'implication et à la motivation des patients (les indicateurs intermédiaires, 2 et 3, ne sont pas documentés ici).*

Cognition about treating T2D: scored from 1: no knowledge about self potential actions to treat T2D, to 4: strong knowledge on what to do in order to attempt reversing T2D
Cognition about nutrients in the body: scored from 1: no knowledge about energy fluxes in the body, to 4: strong knowledge about energy substrates absorption, distribution in the body and use
Emotions and behavior changes: scored from 1: overwhelmed by emotions, contradicts behavior changes, to 4: able to cope with emotions and adapt for actions maintenance
Emotions and physical activity: scored from 1: fear of any physical movement, feeling of danger and vulnerability, to 4: pleasure or joy to be physically active as often as possible
Perception of body feelings: scored from 1: no awareness of body feelings, to 4: capable of adapting behavior to body feelings
Perception of effort intensity during physical activity: scored from 1: no awareness of effort intensity, to 4: excellent estimation of effort intensity at all paces
Infra-cognitive – all or nothing: scored from 1: every action is done to an extreme level or abandoned, to 4: able to adapt behavior in order to maintain the changes over time, despite adverse circumstances
Infra-cognitive – plurifactoral disease: scored from 1: idea that one cause in linked to one disease, to 4: integration of the complexity of the known and unknown causes linked to several diseases
Meta-cognitive – interest in T2D remission: scored from 1: no concern in attempting T2D remission, to 4: the project makes sense for the patient, is meaningful
Meta-cognitive – taking care of personal health: scored from 1: absence of self-care and changing habits interest, to 4: taking care of personal self and engaging in behavior changes is meaningful
Stress management: scored from 1: great difficulties and stress, particularly about the disease, to 4: a project is expressed and strategies are used for stress management
The will to learn: scored from 1: no link between learning and improving health, to 4: curiosity, looks for information and experiments, strong interest in T2D
Quality of Relationship between patient and practitioner, scored from 1: no health care provider with whom patient can exchange views about real life with T2D, to 4: feeling of a deep and emotional relationship with a practitioner, considered close

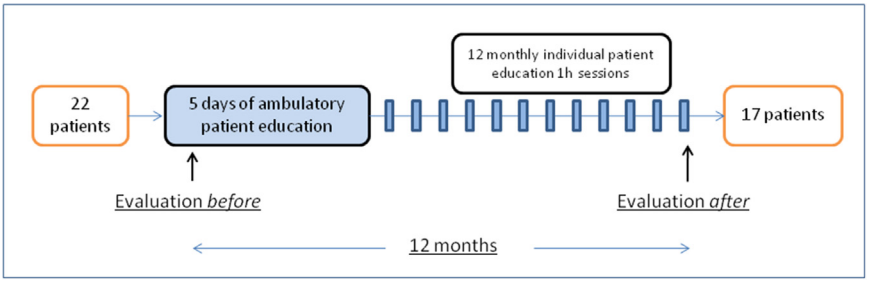

Fig. 1. Schematic outline of the research protocol.
Fig. 1. *Représentation schématique du protocole de recherche.*

Figure 2 shows the variation in HbA_{1C} and ADDs before and after the study, each arrow representing one patient. We observed a reduction of HbA_{1C} with the simultaneous reduction in the number of ADDs taken in 8/17 patients (47.0% of all patients). In one patient, HbA_{1C} decreased with no treatment change, and in 2/17 patients the number of ADDs was reduced, but the HbA_{1C} slightly increased (mean increment of 0.4%). Stable treatment and stable HbA_{1C} values were obtained in 5/17 patients (29%). In one patient, the number of ADDs was increased (+50%) while HbA_{1C} slightly decreased (−0.1%). This means that 11 (65%) patients improved their T2D, 5 stablilized and 1 worsened over the study.

Partial remission of T2D was achieved (green zone of the graph) in 23.5% of the patients (4/17 patients), while good glycemic control (all colored zones representing an $HbA_{1c} < 7.0\%$) was reached by 15 of the 17 patients.

To account for the decrease in HbA_{1C} and the corresponding decrease in drug treatment, a DiaRem-type score was calculated for each patient in the cohort (Fig. 2). This remission probability score shows a significant overall improvement for the cohort over the 12-months follow-up, from 62.5 (±28) to 77.1 (±15) ($p < 0.01$) on average. None of the 17 patients had significantly lowered his/her score during the 12-month follow-up.

Table 5 presents the psychopedagogical scores before and after the 12-month program. There was a tendency to a decrease in anxiety and a slight progression in emotional perception about physical activity. Knowledge about T2D had

Table 3. Baseline characteristics of the 22 patients at inclusion. BMI: body mass index (kg m^{-2}).
Tableau 3. *Caractéristiques de base des 22 patients à l'inclusion. BMI: indice de masse corporelle (IMC) (kg m^{-2}).*

Baseline characteristics of the 22 patients	Mean (± standard deviation)	(min–max)
Number of patients	22	
Men/Women	16/6	
Age	53.4 (± 9.6)	(34–70) years old
Weight	98.9 (± 17.5)	(72–148) kg
Height	170 (± 6.9)	(155–180) cm
BMI	34.1 (± 5.5)	(24.3–46.7) kg m^{-2}
Duration of diabetes (since diagnosis)	2.0 (± 1.9)	(0.1–7) years
HbA_{1C}	7.3 (± 1.9)	(5.1–12.3) %
Antidiabetic drugs (ADDs)/number	2.1 (± 0.9)	(0–4)

Table 4. Bio-clinical values (mean ± SD) of the cohort (17 patients) that completed the study, before and after (12 months) the patient education program. Statistical significance based on unilateral variance analysis.
Tableau 4. *Valeurs biocliniques (moyenne ± SD) de la cohorte (17 patients) ayant complété l'étude, avant et après (12 mois) le programme d'éducation. La significativité est basée sur une analyse statistique de variance unilatérale.*

Variable	Before	After
Weight/kg	96.8 (19.1)	93.4 (16.4)*
BMI/kg m^{-2}	33.9 (5.2)	32.7 (5.6)*
HbA_1c/%	7.2 (1.9)	6.2 (0.8)*
Antidiabetic drugs/number	2.0 (1.0)	1.5 (1.0)***
Adapted DiaRem Score/%	62.5 (28)	77.1 (15)**

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.005$.
BMI: body mass index. ADDs: antidiabetic drugs. DiaRem score (0–100) calculation formula for T2D patients: Probability of remission (in %) = 100–0.45 · (age – 40) – 9 · (HbA_{1C} – 6) – 9 · (number of antidiabetic molecules excluding insulin) – 55 · (1 if patient on insulin treatment, 0 if not) (adapted from Ref. [7]).

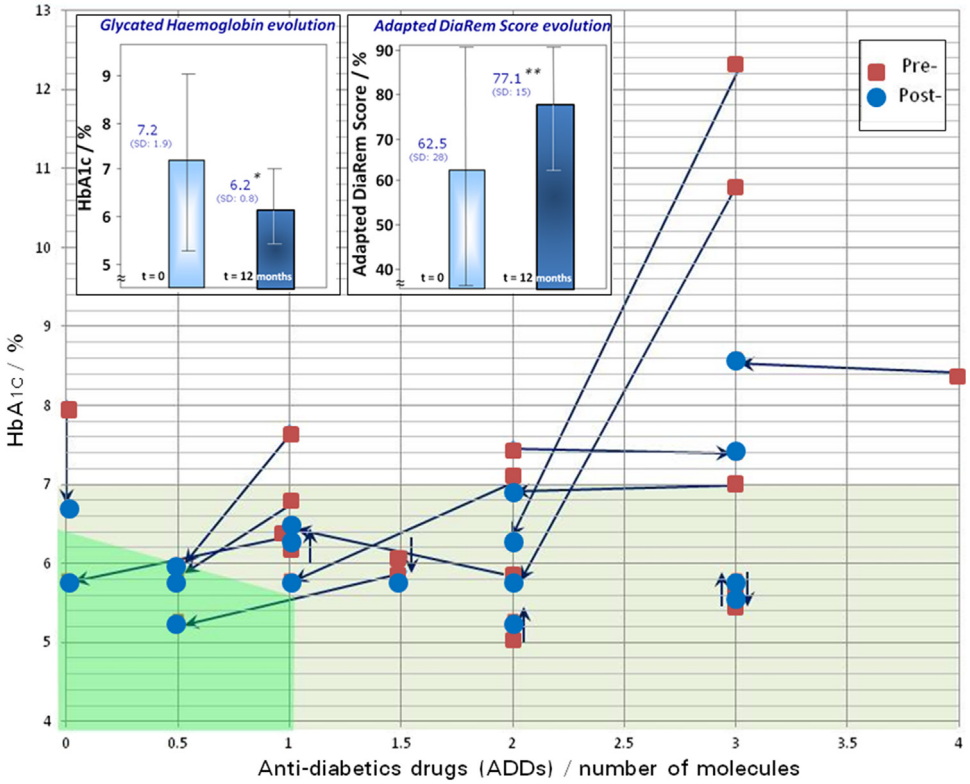

Fig. 2. Variation of HbA_{1c} (vertical axis) and antidiabetic drugs (ADDs, horizontal axis) before (red squares) and after the study (blue discs), for each of the 17 patients. The colored zones represent a "good glycemic control" with an HbA_{1c} below 7%, whereas the green part corresponds to a partial remission of T2D. A complete diabetes remission would see a blue disc on the vertical axis, below 5.7% for the HbA_{1c}. Also shown are the mean HbA_{1c} values and the DiaRem score (probability of T2D remission in %) evolution before/after the therapeutic education program for the 17 patients that completed the study, $^{*}p < 0.05$, $^{**}p < 0.01$.
Fig. 2. *Variation de l'HbA_{1c} (axe vertical) et médicaments antidiabétiques (ADDs, axe horizontal) avant (carrés rouges) et après l'étude (disques bleus), pour chacun des 17 patients. Les zones colorées représentent un « bon contrôle glycémique » avec une HbA_{1c} en-dessous de 7 %, dont la zone verte qui correspondant à une rémission partielle du DT2. Une rémission complète correspondrait à un disque bleu placé sur l'axe vertical, en-dessous de 5.7 % pour l'HbA_{1c}. Les valeurs moyennes d'HbA_{1c} et du score DiaRem (probabilité de rémission du DT2 en %) sont aussi présentées, avant/après le programme d'éducation thérapeutique pour les 17 patients ayant complété l'étude,* $^{*}p < 0.05$, $^{**}p < 0.01$.

Table 5. Psycho-educational scores (mean ± SD) of the cohort (17 patients) that completed the study, before and after (12 months) of the patient education program. Variable range is 1–4, except anxiety and depression which is 0–21.

Tableau 5. *Scores psychopédagogiques (moyenne ± SD) de la cohorte (17 patients) ayant complété l'étude, avant et après (12 mois) le programme d'éducation. La gamme pour les variables est de 1 à 4, excepté pour l'anxiété et la dépression ou elle s'étend de 0 à 21.*

Variable	Before	After
Emotional changing behavior	2.2 (1.0)	2.3 (0.6) *NS*
Emotional physical activity	2.7 (0.9)	3.2 (0.5)*
Cognitive type 2 diabetes	2.5 (0.8)	2.9 (0.6)*
Cognitive nutrients in the body	2.0 (0.8)	2.0 (0.5) *NS*
Perceptive body awareness	2.4 (0.8)	2.5 (0.7) *NS*
Perceptive effort intensity	2.4 (0.9)	2.6 (0.9) *NS*
Infra- all or nothing	2.6 (0.7)	2.9 (0.8) *NS*
Infra- one cause for one disease	2.4 (0.6)	2.8 (0.4)*
Meta- remission is meaningfull	3.4 (0.7)	3.4 (0.7) *NS*
Meta- self care	3.2 (0.7)	3.4 (0.7) *NS*
Anxiety HAD test	7.8 (6.6)	5.7 (4.0) *NS*
Depression HAD test	8.9 (5.8)	9.2 (4.2) *NS*
Stress management	2.3 (0.6)	2.5 (0.7) *NS*
Motivation to learn	2.8 (0.6)	2.5 (0.7) *
Relation with HCP	2.6 (0.8)	3.0 (0.8) *NS*

Statistical significance based on bilateral variance analysis. **probability* $p < 0.05$. Infra-: infra-cognitive dimension. Meta-: meta-cognitive dimension. HCP: health care providers. *NS*: non significant.

increased during the period, especially the idea that it was a multifactorial condition, which is not obvious to many new patients and is partially infra-cognitive. The idea of attempting disease remission seemed very motivating for the patients at the beginning of the study and, despite a very slight decrease over the study period, this motivation to learn and change behavior in order to attempt TD2 reversal was still very high after one year.

4.1 Multivariate correlation analyses

Several correlations were observed. Unsurprisingly, patients with highest HbA_{1c} or lowest DiaRem Score pre-TPE benefitted most from the program, as demonstrated by the observed strong correlation between HbA_{1c} pre-TPE and ΔHbA_{1c} (correlation coefficient = 0.90^{***}), and the strong inverse correlation between the DiaRem score pre-TPE and ΔDiaRem score (-0.83^{***}) at the end of the study. The highest BMI at inclusion correlated to the greatest weight loss during the study. No correlation was found between weight loss and final HbA_{1c} or improved glycemic control (ΔHbA_{1c}), nor between weight loss and changes in the DiaRem score.

The DiaRem score post-TPE was inversely correlated to patient age and duration of T2D (correlation coefficient = 0.49 and 0.66, respectively). We also found an inverse correlation between the DiaRem score pre-TPE and the duration of T2D (−0.49).

No predictive value emerged from the psychopedagogical score before TPE.

5 Discussion

Over the TPE period, glycemic control had improved and intake of antidiabetic drugs was reduced in 11 out of 17 patients while the condition was stable in 5 other patients. Values of HbA_{1c} below 6.5% without treatment, or even less than 5.7% with minimal treatment with metformin are characteristic of a return to the pre-diabetes phase and can be considered as partial remission (a remission of diabetes is defined after a period of at least one year). According to these criteria, 4 out of the 17 patients were in this situation at the end of this study and had a DiaRem score post-study above 90%. This could be explained not only by a reversal of the disease, but also by several other uncontrolled factors. First of all, there is a possibility that patients at inclusion were not taking, or not regularly taking, their antidiabetic medication. Although we aimed to build a high quality relationship with each patient based on trust, the non-disclosure of this information remains a possibility. Another explanation could be that these observations may simply reflect the normal evolution of the disease for naturally motivated patients attaining a better control of T2D despite any intervention. There may also be a transient increase of insulin sensitivity due to regular physical activity and better nutrition, without profound changes in gut hormones and in the liver, pancreas, fat tissue and muscle composition and function. Although these hypotheses are plausible, they cannot be determined without further biomedical investigations such as insulin production and insulin resistance analyses. Finally, there is extensive literature data that highlight this reversal of T2D as a possibility, especially with recently diagnosed patients. It is most probable that our observations are not linked to one but a combination of all these different hypotheses.

Lowering HbA_{1c} in these patients already showing good inclusion values is encouraging, even if the average of 1% decrease in this parameter in our cohort is influenced by the individuals who improved greatly after participating in the study. However, the detailed HbA_{1C} data show that most of the cohort ended up with excellent glycemic control. This is particularly interesting considering the lowering of the antidiabetic treatment during the same period of time. More remarkable, the reversal of the disease, as highlighted here by the ΔDiaRem score, was not correlated to age or weight loss. The fact that this DiaRem score improved without any weight loss, means that it may not alone be a relevant decisional parameter to discriminate patients regarding bypass surgery or very low caloric diets.

According to the literature, intentional weight losses as high as 7 to 14% of initial body weight are typically required for obese T2D patients to allow stopping at least one antidiabetic drug [20]. Our results with much lower weight losses may indicate an increase in physical condition, especially an improvement in muscular insulin resistance, even though we were not able to measure it. However, we also observed that some patients improved strongly during the first months but then lost interest over time.

Table 6. Proposed principles to transfer this prototype research into regular ambulatory practice.
Tableau 6. *Principes proposés pour le transfert de cette recherche prototype à la pratique ambulatoire régulière.*

Evaluating the probability of T2D reversibility: taking into account age, time from T2D diagnosis, medical treatment (number of antidiabetic drugs and insulin), all parameters to include into the DiaRem Score. Other parameters welcome if available (C peptide, antibodies, etc)
Announcement to the patient of a possible T2D reversal: evaluate whether it is a motivating objective for him/her, co-elaborate with him/her the realistic ways to attempt T2D remission
Depending on health system resources, medical and personal environment (patient resources): suggesting actions/workshops/Patient Education/teaching tools, documents, softwares, peer groups, etc. and accompany him/her on his/her learning path by listening to his/her difficulties, by rewarding progress, increasing therapeutic alliance and patient motivation

The clear improvement in the DiaRem score indicates that our approach could be favorable to a reversal of T2D. Achieving a stable glycemic control, encouraged by the patient's practitioner, may be considered enough of an effort for certain individuals. This is probably due to patient empowerment in feeling capable of "reversing the diabetes", but one may sometimes decide that pursuing this goal would be too costly. We also realized that the patient's usual practitioner may show "clinical inertia" to lowering the drug treatment, similar to that described in the literature, which may also partly explain the decrease in patient motivation [31].

The results of this prospective study are promising, particularly in recently diagnosed individuals. Indeed, we found an inverse correlation between the DiaRem score post-TPE and the duration of T2D, reflecting the effect of time after diagnosis on the degradation of T2D. We could suggest that a longer intervention and patient commitment would give more important results over time. However, lifestyle interventions, as reported in the literature, show much less efficient results when the time from diagnosis increases, with strong limitations regarding T2D remission reported at 4 to 10 years post-diagnosis, depending on the study [8,12]. Hence, this is probably not a project that should be proposed to every diabetic patient.

A well-structured 5-dimension TPE program seems to lead to behavioral changes in T2D patients, and we observed knowledge improvement, including some infra-cognitive (subconscious) reasoning. The motivation to learn and change was high at inclusion and remained high at the end of the study.

Limitations of this study are the modest sample size and the absence of a comparator group. This is explained by the difficulty of keeping the possibility of T2D remission a "secret". A comparator group that would not benefit from a patient education program or to whom this possibility of diabetes reversibility is kept secret would be difficult in practice and unethical, considering the motivation effect and rapid results obtained with the inclusion group.

This work could be directly transferred to settings other than ambulatory hospital-centered patient education. A medical doctor, alone or with other health professionals could organize individual or group sessions about "attempting a remission of T2D", in liberal practice, in health centres, or close to where people live or work. Due to the recent epidemiological transition, humanitarian medicine could also benefit from such education, especially in places where patient education could bring big health benefits at low cost. The basic principles and methodology developed in this research that are directly transferable to general practice, are summarized in Table 6.

6 Conclusion

By explaining to recently diagnosed T2D patients that a reversal of their disease might be attainable and by educating them to adapt their behavior, we have demonstrated a regression of the disease over a 1-year period.

Our TPE program takes into account the 5 dimensions of a person: cognitive, emotional, perceptive, infra-cognitive and meta-cognitive. This pedagogic methodology has been developed to help patients understand their disease in detail and act on this information. The program increased the patient‘s knowledge about the disease, while fears about physical activity and some underlying barriers to behavior change, including correct ADDs use, decreased.

The glycemic control of the cohort became excellent with an average HbA_{1C} of 6.2%, coupled with a 25% reduction in the mean number of ADDs used. At the end of the study, two thirds of the cohort reversed their T2D at least partially, and 4 out of 17 patients ended up with parameters compatible with partial diabetes remission. The mean weight loss was only about 3 kg over the period and was not correlated to T2D regression.

This reversal of T2D is probably linked to an increase in physical condition, a better nutrition and a decrease in anxiety and perceived stress, which are usually related to a feeling of powerlessness.

Such a project might be highly motivating for some patients and could be transferred to daily care, at least for a proportion of individuals and during a window of opportunity of several years after diagnosis. Other components of the metabolic syndrome may be reversed to a certain extent, inducing a lowering of the cardiovascular risk and other life-threatening related diseases. This strategy could be long lasting and could be transferred to humanitarian settings and other areas in public health such as prevention.

Patient–researcher

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Conflicts of interest. The authors declare that they have no conflicts of interest in relation to this article.

List of abbreviations

ADDs	Antidiabetic drugs
CCER	Cantonal Commission for Research Ethics of the State of Geneva (in French)
DT2	Diabète de type 2
T2D	Type 2 diabetes
TPE	Therapeutic patient education
HbA_{1C}	Glycated hemoglobin (in %)
BMI	Body mass index (in $kg\,m^{-2}$)

References

1. Steven S, Lim EL, Taylor R. Short Report: Treatment. Population response to information on reversibility of type 2 diabetes. Diabet Med 2013; 30:e135–138.
2. Gregg EW, Chen H, Wagenknecht LE, Clark JM, Delahanty LM, Bantle J, *et al.* Look AHEAD Research Group. Association of an intensive lifestyle intervention with remission of type 2 diabetes. JAMA 2012; 308:2489–2496.
3. Kramer CK, Zinman B, Choi H, Retnakaran R. Predictors of sustained drug-free diabetes remission over 48 weeks following short-term intensive insulin therapy in early type 2 diabetes. BMJ Open Diabetes Res Care 2016; 4:e000270. Doi: 10.1136/bmjdrc-2016-000270.
4. Schauer PR, Bhatt DL, Kirwan JP, Wolski K, Aminian A, Brethauer SA, *et al.* Bariatric surgery *versus* Intensive Medical Therapy for Diabetes – 5-Year outcomes. N Engl J Med 2017; 376:641–651.
5. Sjöström L, Peltonen M, Jacobson P, Ahlin S, Andersson-Assarsson J, Anveden Å, *et al.* Association of bariatric surgery with long-term remission of type 2 diabetes and with microvascular and macrovascular complications. JAMA 2014; 311:2297–2304.
6. Grenier-Larouche T, Carreau AM, Carpentier AC. Early metabolic improvement after bariatric surgery: The first steps toward remission of type 2 diabetes. Can J Diabetes 2017. pii: S1499-2671(16)30048-X. Doi: 10.1016/j.jcjd.2016.10.013.
7. Still CD, Wood GC, Benotti P, Petrick AT, Gabrielsen J, Strodel WE, *et al.* Preoperative prediction of type 2 diabetes remission after Roux-en-Y gastric bypass surgery: a retrospective cohort study. Lancet Diab Endocrinol 2014; 2:38–45.
8. Dixon JB, Chuang LM, Chong K, Chen SC, Lambert GW, Straznicky NE, *et al.* Predicting the glycemic response to gastric bypass surgery in patients with type 2 diabetes. Diabetes Care 2013; 36:20–26.
9. Aminian A, Brethauer SA, Kashyap SR, Kirwan JP, Schauer PR. Correspondence. DiaRem score: external validation. Lancet Diab Endocrinol 2014; 2:12–13.
10. Al-Mrabeh A, Hollingsworth KG, Steven S, Taylor R. Morphology of the pancreas in type 2 diabetes: effect of weight loss with or without normalization of insulin secretory capacity. Diabetologia 2016; 59:1753–1759.
11. Taylor R. Pathogenesis of type 2 diabetes: tracing the reverse route from cure to cause. Diabetologia 2008; 51:1781–1789.
12. Hall TC, Pellen MGC, Sedman PC, Jain PK. Preoperative factors predicting remission of type 2 diabetes mellitus after Roux-en-Y gastric bypass surgery for obesity. Obes Surg 2010; 20:1245–1250.
13. Shah SS, Todkar JS, Shah PS, Cummings DE. Diabetes remission and reduced cardiovascular risk after gastric bypass in Asian Indians with body mass index $< 35\,kg/m^2$. Surg Obes Relat Dis 2010; 6:332–338.
14. Su Y, Zhao Y, Zhang C. Bariatric surgery: beta cells in type 2 diabetes remission. Diabetes Metab Res Rev 2016; 32: 122–131.
15. Lim EL, Hollingsworth KG, Aribisala BS, Chen MJ, Mathers JC, Taylor R. Reversal of type 2 diabetes: normalisation of beta cell function in association with decreased pancreas and liver triacylglycerol. Diabetologia 2011; 54:2506–2514.
16. Cerf ME. Beta cell dynamics: beta cell replenishment, beta cell compensation and diabetes. Endocrine 2013; 44:303–3011.
17. Buse JB, Caprio S, Cefalu WT, Ceriello A, Del Prato S, Inzucchi SE, *et al.* How do we define cure of diabetes? Diabetes Care 2009; 32:2133–2135.
18. Guelpa G. La guérison du diabète. Clermont (Oise) : Impr. De Daix frères et Thiron ; 1910.
19. Kang J, Robertson RJ, Hagberg JM, Kelley DE, Goss FL, DaSilva SG, *et al.* Effect of exercise intensity on glucose and insulin metabolism in obese individuals and obese NIDDM patients. Diabetes Care 1996; 19:341–349.
20. Kumar AA, Palamaner Subash Shantha G, Kahan S, Samson RJ, Boddu ND, Cheskin LJ. Intentional weight loss and dose reductions of anti-diabetic medications – a retrospective cohort study. PLoS One 2012; 7:e32395.
21. Kennedy JW, Hirshman MF, Gervino EV, Ocel JV, Forse RA, Hoenig SJ, *et al.* Acute exercise induces GLUT4 translocation in skeletal muscle of normal human subjects and subjects with type 2 diabetes. Diabete 1999; 48:1192–1197.
22. Holloszy JO. Exercise-induced increase in muscle insulin sensitivity. J Appl Physiol 2005; 99:338–343.
23. Fritz T, Kramer DK, Karlsson HKR, Galuska D, Engfeldt P, Zierath JR, *et al.* Low-intensity exercise increases skeletal muscle protein expression of PPARδ and UCP3 in type 2 diabetic patients. Diab Metab Res Rev 2006; 22:492–498.
24. Ekelund U, Brage S, Griffin SJ, Wareham NJ. Objectively measured moderate-and vigorous-intensity physical activity but not sedentary time predicts insulin resistance in high-risk individuals. Diabetes Care 2009; 32:1081–1086.
25. Fiuza-Luces C, Garatachea N, Berger NA, Lucia A. Exercise is the real polypill. Physiology (Bethesda) 2013; 28: 330–358.
26. Conn VS, Hafdahl AR, Brown SA, Brown L. Meta-analysis of patient education interventions to increase physical activity among chronically ill adults. Pat Educ Couns 2008; 70: 157–172.
27. Lagger G, Sittarame F, Chambouleyron M, Lasserre Moutet A, Müller Pinget S, Haenni Chevalley C, *et al.* Une éducation

thérapeutique pour tenter la rémission du diabète de type 2. Educ Ther Patient/Ther Patient Educ 2016; 8(2):20103

28. Lagger G, Golay A. A 5-dimension therapeutic patient education for type 1 diabetic patients. Educ Ther Patient/Ther Patient Educ 2010; 2(2):S117–S124.
29. Golay A, Lagger G, Giordan A. Comment motiver le patient à changer ? Paris : Maloine ; 2009.
30. Buclin-Thiébaud S, Pataky Z, Bruchez V, Golay A. New psycho-pedagogic approach to obesity treatment: A 5-year follow-up. Pat Educ and Couns 2010; 79:333–337.
31. Reach G, Pechtner V, Gentilella R, Corcos A, Ceriello A. Clinical inertia and its impact on treatment intensification in people with type 2 diabetes mellitus. Diabetes Metab 2017; 43:501–511.

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