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The metabolic control and laboratory evaluation in patients with type 2 diabetes during the COVID-19 pandemic and the impact of telemedicine: a single-center experience

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ABSTRACT

Objective: The study aimed to evaluate the metabolic control during the COVID-19 pandemic in subjects with type 2 diabetes mellitus (T2DM) and whether care through telemedicine significantly impacted it.

Material and methods: This was a retrospective study for which three time-periods were prespecified: the COVID-19 pandemic period, pre-COVID-19 period, and before pre-COVID-19. The following information were collected: anthropometric and laboratory parameters (glycated hemoglobin (HbA1c), blood glucose, lipid profile, creatinine, eGFR, etc.), self-measured blood glucose (SMBG), blood pressure (BP), diabetes therapy, number of on-site and of telemedicine consultations. The mean values of all available measurements for HbA1c, SMBG, BP, weight, and body mass index (BMI) were calculated.

Results: During the COVID-19 pandemic, the HbA1c values increased (6.78±0.77% to 6.96±0.87%, $p<0.0001$; + 0.18±0.67%), despite treatment intensification ($p<0.01$), while BMI and total cholesterol values slightly decreased (32.01±5.5 kg/m^2 to 31.7±5.4 kg/m^2, $p<0.0001$, and 178.1±40.8 mg/dl to 170.5±38.4 mg/dl, $p<0.05$). The deterioration of glycemic control (to HbA1c >7%) were rather seen in males (to 7.01±0.92%, $p<0.0001$), patients from rural areas (to 7.08±0.96%, $p<0.001$) and younger than 65 y.o. (to 7.05±0.82%, $p<0.001$). More male patients had a mean HbA1c increase of >0.5% during the COVID-19 pandemic (32.3% vs 21.5%, $p<0.05$). Patients who received more diabetes care visits through telemedicine had a more attenuated increase in HbA1c (6.79±0.80% to 6.90±0.83%, $p<0.05$ vs 6.76±0.72% to 7.08±0.92%, $p<0.0001$).

Conclusions: The glycemic control slightly deteriorated during the COVID-19 pandemic (but with overall HbA1c within target), with certain patient categories being more affected. Diabetes care though telemedicine allowed the maintenance of the metabolic control.

Keywords: type 2 diabetes, COVID-19, telemedicine

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INTRODUCTION

The Coronavirus Disease 2019 (COVID-19), an infectious disease caused by the Severe Acute Respiratory Syndrome CoronaVirus 2 (SARS-CoV-2), was classified in March 11 2020 by the World Health Organization (WHO) as a pandemic disease [1]. It has affected a great number of individuals worldwide, being associated with a multitude of medical and socio-economic outcomes [2, 3]. As of October 5th 2022, there have been 616,427,419 confirmed COVID-19 cases, and 6,528,557 deaths have been reported, according to the WHO data [4].

SARS-CoV-2 primarily targets the respiratory system, but many other systems might be affected (i.e., cardiovascular, gastrointestinal/ hepatobiliary, central nervous system, renal, hematologic, endocrine, etc.) resulting in various dysfunctions/ manifestations, including long-term ones [2, 5, 6]. COVID-19 also increases the risk of new-onset diabetes mellitus (DM), through various putative mechanisms, such as direct or indirect viral effects on the β-cells, stress or steroid-induced hyperglycemia [7, 8]. On the other hand, the impaired metabolic health affects the COVID-19 outcomes, as diabetes and obesity have emerged as important risk factors for severe

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disease, including higher risk of mortality, more severe complications, longer duration of hospitalization, etc. [2, 9-11]. Not only that type 2 DM (T2DM) patients, for example, had a significantly higher risk of multiple organ injury and mortality, and required more intensive in-hospital therapy than subjects without DM, but the degree of glycemic control significantly impacted these outcomes: well-controlled blood glucose levels were correlated with lower risk of mortality (adjusted HR: 0.14 [95%CI: 0.03–0.60]; p=0.008) and of composite adverse outcomes during hospitalization compared to poorly controlled glycemia [10].

However, the management of diabetes posed real challenges during the COVID-19 pandemic. Apart from the higher risk of severe outcomes and exacerbated comorbidities due to the SARS-CoV-2 infection, the access to healthcare facilities was limited, mainly during the first waves, as lockdown, quarantine, social distancing, and other measures were implemented in order to limit the spread of the disease [12, 13]. These restrictive measures also negatively affected the physical activities and the diet (dietary choices/food supplies) of patients with DM, which in turn resulted in undesirable consequences on the metabolic control [14, 15]. The alteration of the glycemic control not only increases the risk of DM chronic complications, but also augments the risk of severe COVID-19 outcomes, thus creating a vicious cycle.

The management of DM usually requires periodic face-to-face interactions with the healthcare providers, but during the COVID-19 pandemic alternative technology-based methods and strategies have been implemented, in order to support patients and provide continued healthcare services [16]. Telehealth turned out to be crucial for delivery of these services to DM patients and was widely used throughout the pandemic [17]. It was provided through videoconferences or telephone calls, if the necessary technologies were not available. Moreover, the use of telemedicine protocols and digital technologies in a virtual diabetes/ metabolic clinic might have the potential to mitigate several challenges in the DM healthcare, such as access to care for people living in remote areas or with disabilities, reduced time and costs (i.e., with transportation), improved patient satisfaction/ comfort and efficiencies, etc. [18]. However, these advantages should be obtained with the condition of maintaining a good quality of care and an optimal metabolic control.

The aim of this study was to evaluate the changes in the metabolic control during the COVID-19 pandemic in T2DM subjects and whether care through telemedicine had significant impact on maintaining the glycemic control.

MATERIAL AND METHODS

This was a retrospective study that collected data from the medical records of T2DM patients registered in the outpatient unit of the Emergency County Clinical Hospital of Târgu Mureș, Romania. The study was approved by the Ethics Committee of the Emergency County Clinical Hospital of Târgu Mureș. The inclusion criteria were T2DM for at least three years at the time when the COVID-19 pandemic started (March 2020), managed with antihyperglycemic medication and/ or insulin, with a minimum set of data (HbA1c, weight, blood pressure and at least self-measured fasting blood values) before and during the pandemic period. Exclusion criteria were other types of diabetes mellitus (type 1, gestational or secondary diabetes), missing information from the minimum data set, diabetes duration less than 3 years.

We prespecified three time periods for the data collection: the COVID-19 pandemic period (from March 15th, 2020, when the state of emergency due to COVID-19 was declared, until March 15th, 2022), pre-COVID-19 period (from March 15th, 2018 until March 15th, 2020), and for additional comparisons, the period before pre-COVID-19 (from 2016 until March 15th 2018). The patients received care through telemedicine during the pandemic (not applicable before) by telephone contact, but other remote communication methods were used (i.e., emails, for some information collection, when applicable). Whenever needed (e.g., initiation of injectable therapy, significant deterioration of glycemic control, etc.), the patients were invited to the diabetes clinic for a face-to-face visit.

The following data were collected in this study: demographic data (age, sex, marital status, smoking status, occupation), anthropometric parameters (height, weight), laboratory data (glycated hemoglobin (HbA1c), fasting blood glucose, total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, aspartate aminotransferase (AST), alanine aminotransaminase (ALT), creatinine, uric acid) (as available at a single time-point), fasting and post-prandial self-measured blood glucose, blood pressure, the number of visits to the diabetes clinic, and the number of telemedicine consultations during the COVID-19 pandemic. Whenever applicable (if not already calculated), the Friedewald formula was used to calculate the LDL cholesterol (for triglyceride values under 400 mg/dl), and the estimated glomerular filtration rate (eGFR) was calculated with the CKD-EPI formula. During the COVID-19 pandemic, weight and blood pressure were measured by patients and reported during the diabetes telemedicine visits. Current diabetes medication at the end of each specified period was also included. The body mass index (BMI) was calculated by weight/height^2 (kg/m^2). For the three time periods, the mean values of all available measurements for HbA1c, self-measured fasting blood glucose, self-measured postprandial blood glucose (where available), systolic and diastolic blood pressure (SBP and DBP), body weight, BMI were calculated and reported here.

The statistical analysis was done by using GraphPad InStat3 software. The normality of data was tested with the Kolmogorov-Smirnov test. The Student t test, Mann-Whitney test, ANOVA and Kruskal-Wallis tests were used, respectively, to compare means and medians between groups, while for the comparison of data from the same group in different time periods, the repeated measures ANOVA (with Friedman test with post-test) was employed. The Fisher's exact test/ Chi-square test were also used for the analysis of categorical variables. All used tests were two-tailed and the statistical significance was set at p <0.05.

RESULTS

Data from 328 T2DM patients were included in this analysis and their baseline characteristics are presented in Table 1. At the beginning of the COVID-19 pandemic the median age of the patients was 67.1 [25-89] years, and the median duration of diabetes was 9.1 [3-32] years.

The metabolic control during the COVID-19 pandemic period

We evaluated the changes in metabolic parameters during the COVID-19 pandemic as compared to the pre-COVID-19 period. The mean body weight (BW) and the BMI decreased (from 88.7±17.4 kg to 87.8±17.0 kg, and from 32.01±5.5 kg/m^2 to 31.7±5.4 kg/m^2, respectively, p<0.0001 for both), while the HbA1c increased (from 6.78±0.77% to 6.96±0.87%, p<0.0001) and the self-measured fasting blood glucose did not change significantly (123.4±13.3 mg/dl versus 124.4±14.6 mg/dl; p: NS). The self-measured postprandial blood glucose values during both times were available in 231 T2DM patients, and the change was not significant (159.1 ±35.6 mg/dl versus 161.7±32.2 mg/dl, p: NS). The increase in HbA1c was observed despite significant treatment intensification, with higher number of patients receiving a GLP-1 receptor agonist, a SGLT2 inhibitor and insulin therapy during COVID-19 pandemic versus the pre-COVID-19 period (p=0.006) (table 2). The mean SBP basically remained similar (132.6±11.4 mmHg versus 133.2±9.3 mmHg, p: NS), but the mean DBP increased during the COVID-19 period (from 77.1±5.6 mmHg to 78.7±6.5 mmHg, p<0.0001).

During the COVID-19 pandemic, the full-parameter laboratory assessment was done, most of the time, either by referral from the family physician or during various hospitalizations. Therefore, in some patients, an incomplete set of metabolic/biochemistry parameters were available. If available during both time periods, we evaluated the changes in lipid profiles and eGFR. The HDL cholesterol values were missing in 67 patients at both times, and LDL cholesterol was available in 255 of them (for 6 patients, LDL cholesterol values could not be calculated due to high triglyceride values). The total cholesterol concentrations slightly decreased (from 178.1±40.8 mg/

Table 1. Baseline characteristics of T2DM patients included in the study

Baseline demographic and medical parameters	
Sex (F/M) (%)	48.2/51.8
Residency (U/R) (%)	61.9/38.1
Employment status (E or SE/UE or Rt) (%)	15.9/84.1
Marital status (Ma/S or D or W) (%)	79.6/20.4
Smoking status (Sm/ExS/NSm) (%)	17.1/43.3/39.6
BMI (kg/m^2)	32.2 [21.4-52.4]
Systolic blood pressure (mmHg)	132.5 [77.5-172.5]
Diastolic blood pressure (mmHg)	77.5 [60.0-95.0]
Self-monitored fasting blood glucose (mg/dl)	124.7 [87.5-224.0]
HbA1c (%)	6.69 [4.6-9.95]
Lab-based fasting blood glucose (mg/dl)	128.0 [67.0-476.6]
Total cholesterol (mg/dl)	183.1 ± 42.1
HDL-cholesterol (mg/dl)	46.0 [21.0-97.0]
LDL-cholesterol (mg/dl)	103.9 [31.9-206.0]
Triglycerides (mg/dl)	147.2 [45.0-854.4]
eGFR (ml/1.73 m^2/min)	81.2 [27.2-144.7]
AST (U/l)	21.0 [9.6-99.0]
ALT (U/l)	26.0 [7.4-167.0]
Uric acid (mg/dl)	5.5 [2.6-10.1]

F= females; M=males; U=urban; R=rural; E=employed; SE=self-employed; UE=unemployed; Rt=retired; Ma=married; S=single; D=divorced; W=widow; Sm=smoker; ExS=ex-smoker; NSm=non-smoker; BMI=body mass index; HbA1c=glycated hemoglobin; eGFR=estimated glomerular filtration rate; AST=Aspartate aminotransaminase; ALT=Alanine aminotransaminase; data is presented as mean ± SD or median [min-max]

Table 2. The change in diabetes therapy during COVID-19 pandemic versus the pre-COVID period

Antihyperglycemic medications	Before Pre-COVID-19 pandemic	Pre-COVID-19 pandemic (2018-2020)	During COVID-19 pandemic (2020-2022)
		p<0.0001	
Metformin (nr/%)	308 (93.9)	306 (93.3)	307 (93.6)
Sulphonylureas (nr/%)	94 (28.7)	76 (23.2)	76 (23.2)
DPP-4 inhibitors (nr/%)	33 (10.1)	35 (10.7)	25 (7.6)
GLP-1 RA (nr/%)	21 (6.4)	66 (20.1)	88 (26.8)
SGLT-2 inhibitors (nr/%)	8 (2.4)	25 (7.6)	57 (17.4)
Insulin (nr/%)	60 (18.3)	79 (24.1)	100 (30.5)

DPP-4=dipeptidyl peptidase; GLP-1RA=Glucagon-like peptide-1 receptor agonists; SGLT-2= Sodium-glucose co-transporter-2

dl to 170.5±38.4 mg/dl, p=0.021; n=311), the LDL cholesterol levels decreased non-significantly (101.1±34.1 mg/dl versus 95.5±35.0 mg/dl; p=0.07; n=255), while the HDL cholesterol (46.1±12.2 mg/dl versus 45.1±12.2 mg/dl; n=261), and triglycerides (169.2±93.0 mg/dl versus 161.5±78.2 mg/dl; n=306) remained the same (p: NS for both). For 302 patients, the calculated eGFR values were available in both time periods, and indicated a non-significant decrease (77.7±21.3 ml/1.73m^2/min versus 75.8±21.9 ml/1.73m^2/min, p=0.09).

We further performed subgroups analysis in order to identify patient categories that were mostly affected by the COVID-19 pandemic in terms of metabolic control (Figure 1).

First, data was analyzed according to residency. The mean age of patients living in rural areas was similar to those living in urban areas (64.9±9.6 years versus 65.2±9.1 years), and they had a similar diabetes duration (9.0±3.9 years versus 9.1±4.3 years) (p: NS for both). T2DM patients living in rural areas had a small but significant decrease in BMI (from 32.6±5.6 kg/m2 to 32.3±5.4 kg/m2, p=0.012) and a significant reduction in total cholesterol levels (from 182.1±42.2 mg/dl to 171.1±46.0 mg/dl, p=0.013; n=117). Similarly, the T2DM patients from urban areas presented a slight decrease in BMI (from 31.6±5.4 kg/m^2 to 31.3±5.3 kg/m^2, p=0.001), but the total cholesterol levels did not change (175.6±39.9 mg/dl versus 170.1±38.1 mg/dl, p: NS; n=194). The change in mean fasting self-measured blood glucose was not significant in either subgroup (124.7±13.6 mg/dl versus 125.6±14.7 mg/dl in rural subgroup, and 122.7±13.1 mg/dl versus 123.4±14.4 mg/dl for urban subgroup; p: NS for both).

On the other hand, the mean HbA1c significantly increased in both groups (from 6.86±0.78% to 7.08±0.96%, p=0.0006 for rural subgroup, and from 6.73±0.77% to 6.89±0.8%, p=0.0009 for urban group). At the end of COVID-19 period, a slightly higher percentage of T2DM subjects living in rural area had an HbA1c level >7%, but the difference was not significant (45.6% versus 35.4%; p=0.08).

Secondly, the metabolic changes were evaluated according to gender. There was no difference with regards to age (65.5±9.3 years versus 64.6±9.3 years) or diabetes duration (9.1±4.2 years versus 9.1±4.0 years) between genders (p: NS for both). Both female and male T2DM patients presented a slight decrease in BMI (from 32.3±6.2 kg/m^2 to 32.0±6.0 kg/m^2, p=0.019 in females, and from 32.3±6.2 kg/m^2 to 32.0±6.0 kg/m^2, p=0.019 in males). The total cholesterol levels decreased in female T2DM patients, but with borderline non-significance (from 182.9±39.8 mg/dl to 175.7±40.4 mg/dl, p=0.055; n=148), while for men the reduction was significant (from 173.6±41.3 mg/dl to 165.7±36.1 mg/dl, p=0.039; n=163). Female T2DM patients presented a significant rise both in systolic and diastolic BP during the COVID-19 period (SBP: from 130.0±11.3 mmHg to 132.5±10.0 131.5 mmHg, p=0.003; DBP: from 76.0±5.3 mmHg to 78.0±6.8 mmHg, p<0.0001). For male patients, a small non-significant decrease in SBP was noted (135.1±11.1 mmHg ver-

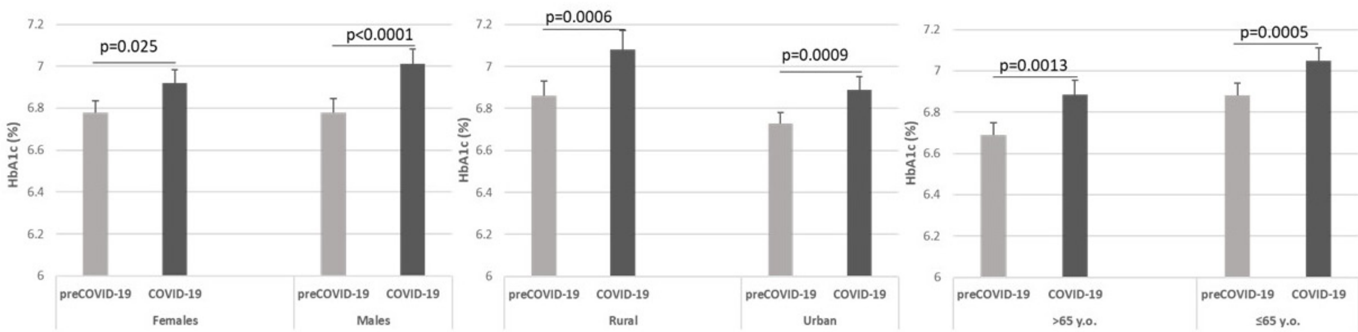

Fig. 1. Changes in mean HbA1c values in several T2DM patient subgroups during the COVID-19 pandemic.

sus 133.8±8.5 mmHg, p=0.08), while the DBP increased (from 78.1±5.6 mmHg to 79.3±6.2 mmHg, p=0.002).

Both female and male subjects presented a significant increase in mean HbA1c (from 6.78±0.7% to 6.92±0.8%, p=0.025 in females, and from 6.78±0.83% to 7.01±0.92%, p<0.0001 in males). In addition, significantly more male patients had an increase in mean HbA1c of more than 0.5% during the COVID-19 pandemic years (32.3% versus 21.5%, p=0.034).

Thirdly, we analyzed data according to age. Patients older than 65 years of age had a small but significant decrease in BMI (from 31.6±5.5 kg/m^2 to 31.2±5.4 kg/m^2, p=0.0004), as did the patients younger than 65 years (from 32.5±5.5 kg/m^2 to 32.2±1.3 kg/m^2, p=0.018). The total cholesterol levels did not significantly change in the two age categories, and neither did the self-measured fasting blood glucose. Both age categories had a significant raise in HbA1c (from 6.69±0.76% to 6.88±0.91%, p=0.0013 for patients older than 65 years of age, and from 6.88±0.78% to 7.05±0.82%, p=0.0005 for patients ≤ 65 years old). Older patients had a significant reduction in renal function (eGRF decreased from 70.6±21.4 ml/1.73m^2/min to 67.1±20.3 ml/1.73m^2/min, p=0.025; n=157), while in younger T2DM individuals, the change was not significant (85.3±18.5 ml/1.73m^2/min versus 85.2±19.6 ml/1.73m^2/min, p: NS; n=145). Only patients younger than 65 had an increase in DBP (77.3±5.4 mmHg to 79.2±6.0 mmHg, p<0.0001), but the SBP did not change (132.0±10.9 mmHg versus 132.7±9.1 mmHg, p: NS).

Finally, we compared the mean HbA1c values during the COVID-19 period with the mean HbA1c values during the pre-COVID19 period and with the mean of the last two HbA1c values measured before the pre-COVID-19 period (before March 2018) in order to decipher the effect of COVID-19 pandemic on the glycemic control from the natural progression of the disease itself. We found a progressive elevation of HbA1c during the three time periods (p<0.0001) (figure 2), with an increase of a slightly greater (but non-significant) extent during COVID-19 pandemic (0.18±0.67% versus 0.09±0.61%, p: NS). The change in diabetes specific therapy during the three time periods is noted in table 2 (p<0.0001). A similar analysis of BMI changes showed that the mean BMI values decreased from 32.2±5.4 kg/m^2 (before pre-COVID-19 period) to 32.0±5.5 kg/m^2 (during pre-COVID-19 period) and to 31.7±5.4 kg/m^2 (during COVID-19 pandemic years) (p<0.0001).

The influence of diabetes care through telemedicine on the metabolic control

We subsequently investigated the impact of telemedicine on the metabolic control in T2DM patients by comparing the metabolic parameters in the two periods of time according to the number of telemedicine visits during the COVID-19 pandemic. Overall, during the pandemic years, the patients had between 6 and 10 total visits for diabetes management (median: 8), of which between 0-10 visits (median 7) were performed through telemedicine. Before the pandemic, all diabetes visit were performed onsite, face-to-face, most with a diabetes specialist (median number 7.0 [3-11]).

During the COVID-19 pandemic the median percentage of telemedicine visits was 87.5%, and therefore, we divided the study data into two subgroups (above and below the median value). The T2DM patients having more telemedicine visits were younger (64.3±9.6 years versus 66.4±8.5 years, p=0.046), but the duration of diabetes was similar (9.1±4.1 years versus 9.2±4.1 years, p: NS). The mean HbA1c levels were similar between the two groups during pre-COVID-19 period. Both subgroups presented a significant increase in HbA1c during the COVID-19 period, but the mean difference in HbA1c values increased less in subjects receiving more telemedicine diabetes consultations (0.11±0.66% versus 0.32±0.69%, p=0.012), and only the group receiving less telemedicine visits had an increase to mean HbA1c values above 7%. The main metabolic data is presented in Table 3. Apparently, subjects with more telemedicine visits during the pandemic years, had a small but significant decrease in BMI and total cholesterol levels.

DISCUSSIONS

We performed an observational retrospective study in order to evaluate the changes in the metabolic control of patients with T2DM from a single diabetes center from the central part of Romania during the COVID-19 pandemic, as well as the impact of telemedicine on the metabolic parameters. We found that during the pandemic

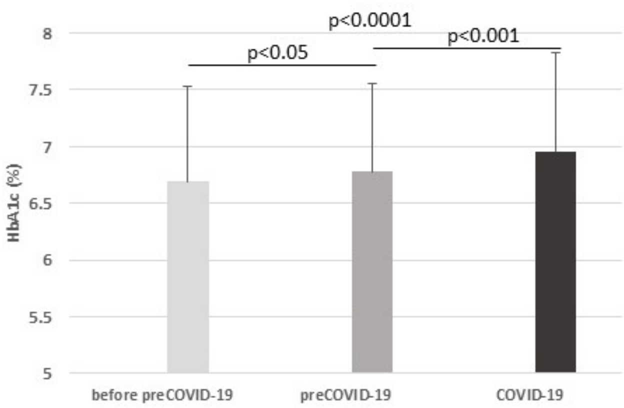

Fig. 2. Changes in mean HbA1c values during the three pre-specified time periods (data presented as mean and SD).

Table 3. Changes in main metabolic data during COVID-19 pandemic according to the percentage of telemedicine visits

	< 87.5% telemedicine visits			≥ 87.5% telemedicine visits		
	pre-COVID-19	**COVID-19**	**p**	**pre-COVID-19**	**COVID-19**	**p**
HbA1c (%)	6.76±0.72	7.08±0.92	<0.0001	6.79±0.80	6.90±0.83	0.021
BMI (kg/m^2)	32.2±5.2	32.0±5.2	0.063	31.9±5.6	31.5±5.5	0.0002
Fasting SMBG (mg/dl)	124.4±13.5	124.5±13.6	0.447	122.9±13.2	124.1±15.1	0.209
Total cholesterol (mg/dl)	180.2±40.9[a]	171.4±39.2	0.232	176.8±40.9[b]	169.9±38.2	0.043

[a]n=113; [b]n=198; SMBG= self-measured blood glucose

years the HbA1c values increased slightly, despite treatment intensification. The results are in concordance with some but not all studies that evaluated the glycemic control during COVID-19 pandemic in patients with T2DM, as some of them showed deterioration of HbA1c values, others indicated an improvement, and others reported no change [19-22]. However, our results are in accordance with a systematic review that included data from 1823 patients with T2DM (and showed a mean increase in HbA1c of +0.14 [95%CI: −0.13 to 0.40]), and with the results of a meta-analysis of 11 studies (n=16,895) indicating a significant increase of HbA1c levels (0.34% [95%CI: 0.30 to 0.38]) during the COVID-19 pandemic [23, 24]. Nevertheless, most if not all studies compared the glycemic control during COVID-19 pandemic with the immediately previous period. We performed an additional comparison with the metabolic control during the period of time before the pre-COVID-19 years, in order to observe the impact of COVID-19 pandemic versus the natural progression of the disease itself. Indeed, we found a progressive deterioration of glycemic control (but the mean HbA1c was still below 7%) during the three studied periods, with a slightly greater (but non-significant) increase during the COVID-19 pandemic years.

As most visits for diabetes management occurred through telemedicine during the pandemic period, the results indicated that this did not negatively influence the metabolic control of patients with T2DM. In fact, the subsequent analysis by the number of telemedicine visits indicated that patients receiving more telemedicine visits had an attenuated deterioration of glycemic control. A retrospective study in T2DM from Australia reported a slightly better glycemic control for patients who received care via telehealth consultations during the COVID-19 pandemic [25]. However, it should be noted that, at least in our study, the telemedicine visits were performed with patients who did not have a significant deterioration of glycemic control, and those who presented an alteration of the blood glucose control/needed initiation of injectable therapy were invited to the clinic for a face-to-face visit. As shown by our study data, this strategy allowed the maintenance of a good metabolic control, thus diabetes management plans that include telemedicine consultations with a diabetes specialist might be a good alternative at least for some patients.

The subgroups of patients that presented a greater glycemic deterioration based on HbA1c values to mean values higher than 7.0% were males, from rural areas and younger than 65 years of age (although females, older patients and those living in urban areas also had a modest increase of HbA1c). Contrary to our findings, a similar study from Japan found that rather females and patients aged ≥ 65 years had a deterioration of HbA1c levels [19]. The differences between these results are not clear, but it might be that in our study population, males, younger patients, and those with rural residency had greater changes in lifestyle/ diet and physical exercise, and perhaps in the levels of psychological stress.

The weight and BMI of the patients included in our study decreased during the pandemic years. This finding is opposed to the meta-analysis by Ojo O. et al., which reported a BMI increase of 1.13 [95%CI: 0.99; 1.28], $p<0.05$ (5 studies; n=2363 patients) [24]. However, not all studies demonstrated this effect on body weight, with some reporting a decrease or no significant change [19, 25-27]. The decrease of body weight and BMI observed in our study might have several explanations: first, during the COVID-19 pandemic, the body weight was self-measured and reported by patients and there might be scale differences and/or tendency to underreport the real weight; secondly, during the COVID-19 significantly more patients received treatment with a GLP-1 receptor agonist and/or a SGLT-2 inhibitors, which favor weight loss; and thirdly, we cannot exclude that some patients changed their eating habits (before) and during COVID-19 pandemic. In fact, a study from France analyzed the eating habits and weight changes in patients with diabetes and overweight/obesity and found that some patients improved their eating behaviors (had higher intake of fruits and vegetables, and lower intake of snacks) during the pandemic, which was associated with improvement in body weight [26]. Nevertheless, given that the improvement in BMI was seen even before the pandemic, changes in diabetes therapy and improvement in lifestyle might be the most plausible explanations in our study population.

In fact, the change in eating habits might also explain the small change in the total cholesterol levels we noticed in the overall study group and those living in rural areas, although we did not directly investigate the dietary consumption of the patients during or before pandemic. Also, a limitation of the study was that we did not have exact information regarding the statin use for all patients.

The study results indicated an increase in diastolic blood pressure in the overall population, and specifically in younger and male patients, while female subjects presented a significant increase in both systolic and diastolic blood pressure. The results are consistent with the findings of other studies showing deterioration of blood pressure control during the pandemic years [28, 29]. Apparently, weight gain was not the cause of BP increase in our study population, thus rather other possible causes might explain it, such as changes in medication adherence and diet (including higher alcohol intake), reduced physical activity, but also higher psychological stress and anxiety, which might have had a different impact on certain patient categories [30]. In fact, it was shown that the prevalence of anxiety increased significantly (with 25.6%) during COVID-19 pandemics, with females and younger people being more affected [31].

Our study has several limitations. First, it was a single center retrospective study, conducted at a university hospital, which might not be nationwide representative. Secondly, we did not have postprandial blood glucose measurements available in all subjects, thus we could not objectify if the deterioration of glucose control was due to an increase in postprandial glycemic values. Thirdly, we did not have information about the lifestyle and psychological changes during the pandemic years to better understand the reasons for the alteration in cardiometabolic health. Nevertheless, this is, to our knowledge, the first study in Romania investigating the changes in the metabolic parameters during the COVID-19 pandemic in patients with T2DM, compared to the pre-COVID-19 period (and the period of time before that), as well as the impact of care through telemedicine on the metabolic control in T2DM.

CONCLUSIONS

The study demonstrated that the glycemic control of patients with T2DM slightly deteriorated during the COVID-19 pandemic years (but with overall mean HbA1c within target), with certain categories being more affected (males, younger patients and those living in rural areas). Diabetes care though telemedicine during the COVID-19 pandemic allowed the maintenance of the metabolic control in patients with T2DM.

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AUTHOR’S CONTRIBUTION

CRO: substantial contribution to the acquisition of data, revised the work for important intellectual content, ÁE: contribution to the acquisition of data, revised the work for important intellectual content, ALR: contribution to the acquisition of data and writing of manuscript, revised the work for important intellectual content, SC: conception and design of the work, analyzed and interpreted the data, wrote the manuscript and revised the work for important medical content. All authors have approved the final version.

CONFLICT OF INTEREST

None to declare.

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