DIABETES TECHNOLOGY & THERAPEUTICS
Volume 23, Number 5, 2021
© Mary Ann Liebert, Inc.
DOI: 10.1089/dia.2020.0556

LETTER TO THE EDITOR

Remote Glucose Monitoring Platform for Multiple Simultaneous Patients at Coronavirus Disease 2019 Intensive Care Units: Case Report Including Adults and Children

Fabricio Garelli, PhD,[1,2] Nicolás Rosales, PhD,[1,2] Emilia Fushimi,[1,2] Delfina Arambarri,[1,2] Leandro Mendoza,[1] Hernán De Battista, PhD,[1,2] Ricardo Sánchez-Peña, PhD,[2,3] Julia García Arabehety, MD,[4] Sabrina Distefano, MD,[4] Consuelo Barcala, MD,[5] Javier Giunta, MD,[4] Marcos Las Heras, MD,[4] Carolina Martinez Mateu, MD,[5] Mariana Prieto, MD,[5] Eduardo San Román, MD,[4] Gabriela Krochik, MD,[5] and Luis Grosembacher, MD[4]

Dear Editor,

From the beginning of the pandemic, a lot of articles have been written about the relevance of technology and remote glucose monitoring to deal with diabetes within the present context.[1] However, not so many reports have been published on its actual implementation in critically ill patients. In Ushigome et al.,[2] a single case of glucose monitoring in a critical patient was reported, using a Continuous Glucose Monitor (CGM) Dexcom G4, which should be read at a maximum distance of 6 m from the patient. In Shehav-Zaltzman et al.,[3] four patients were remotely monitored using Medtronic CGMs and web-app CareLink accessed through minimized browser windows. Finally, remote monitoring with Dexcom G6 was evaluated using Dexcom Follow app in Reutrakul et al.[4] for noncritical patients with coronavirus disease 2019 (COVID-19). Other relevant telemetry studies worth to mention that controlled multiple patients without COVID-19 are Beardsall et al.[5] and Singh et al.[6]

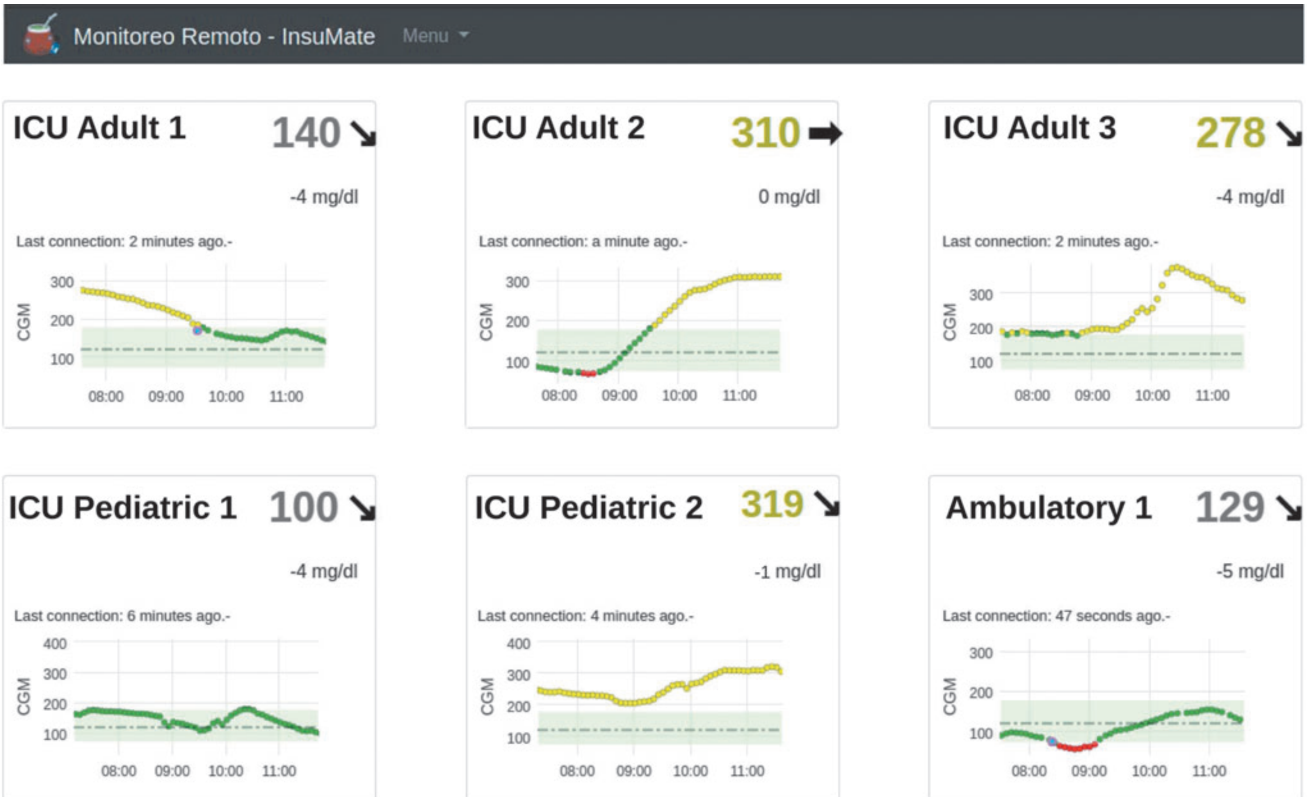
This letter illustrates the potential of a new platform for simultaneous remote monitoring of multiple intensive care unit (ICU) and/or quarantined patients. To our best knowledge, this is the first multicenter, multisensor, multipatient, and potentially multitherapy platform for remote glucose monitoring employed in critically ill COVID patients. We report the real-time remote monitoring of five COVID-19 positive ICU patients, two children and three adults, together with an ambulatory patient to test the platform versatility and long-term performance. As far as we know, also, this is the first multiple ICU monitoring experience, including critical pediatric COVID positive cases.

The monitoring platform was developed from open-source resources and is available online (www.insumate.com.ar), it runs on an own server allowing user profiles management with up to 40 simultaneous patients for each Health Center. Furthermore, it allows using different CGMs (e.g., Dexcom, Medtronic, or Abbott) and is completely configurable in a remote way. The Dexcom G6 CGM system was used to monitor glycemic evolution of the ICU patients, whereas a FreeStyle Libre 1 with a Miao Miao 2 Bluetooth adapter was employed for the quarantined testing patient. The accuracy of the Dexcom G6 was recently evaluated in hospitalized patients, concluding that it could be used safely in patients infected with *Severe Acute Respiratory Syndrome Coronavirus 2* (SARS-CoV-2).[7] On the contrary, the use of flash sensors was limited to nonhospitalized cases.

Figure 1 shows the general view of the platform and the main monitoring outcomes. In the detailed view of each patient (not shown), up to eight days of glucose evolution can be observed and zoomed, whereas the most relevant metrics are automatically uploaded day by day. It is worth highlighting the excellent connectivity of the platform despite the complex ICU environment.

For the glucose control of ICU patients our institutions use insulin-therapy protocols that aim at achieving glucose levels ranging from 140 to 180 mg/dL, with insulin infusions close to 0.2 IU/(kg · d) in children and between 0.7 and 1.4

[1]Group of Control Applications, LEICI, Universidad Nacional de La Plata (UNLP), La Plata, Argentina.
[2]CONICET, Argentina.
[3]Centro de Sistemas y Control, Instituto Tecnológico de Buenos Aires, Buenos Aires, Argentina.
[4]Hospital Italiano de Buenos Aires, Buenos Aires, Argentina.
[5]Hospital de Pediatría J. P. Garrahan, Buenos Aires, Argentina.



	ICU Adult 1	ICU Adult 2	ICU Adult 3	ICU Pediatric 1	ICU Pediatric 2
Age (years) / Gender	68 / F	63 / M	77 / F	12 / M	14 / F
Diabetes type	Type 2	Type 2	Type 2	COVID-induced	Post-transplant
Glucose management before CGM					
Mean blood glucose tests/day	14.4	7.9	19.4	8.7	5.4
Mean ± SD BG (mg/dL)	206.3 ± 77.7	195.5 ± 38.6	201.1 ± 67.0	262.0 ± 102.5	413.7 ± 142.0
Glucose management with remote real-time CGM					
On-line monitoring duration	4d 21h 5m	9d 16h 40m	5d 17h 00m	4d 23h 40m	8d 23h 55m
Time with transmitted data (%)	99.4	100	100	100	100
Mean blood glucose tests/day	5.9	4.0	8.0	4.1	4.0
Mean ± SD BG (mg/dL)	183.4 ± 58.4	200.8 ± 53.0	186.3 ± 53.5	183.5 ± 39.3	267.1 ± 75.3
TAR 180-250 / >250 mg/dl (%)	34.8 / 12.5	42.3 / 16.9	41.2 / 11.7	50.5 / 3.3	32.5 / 54.7
TIR 70-180 mg/dl (%)	51.6	40.8	46.9	46.2	12.8
TBR <70 / <54 mg/dl (%)	1.1 / 0.1	0.0 / 0.0	0.2 / 0.0	0.0 / 0.0	0.0 / 0.0
CV (%)	31.8	26.4	28.7	21.4	28.2

FIG. 1. General view of Insumate® multipatient platform, and main monitoring results. Adult cases were monitored at ICU-COVID of Hospital Italiano de Buenos Aires and pediatric cases at ICU-COVID of Hospital de Pedriatría J.P. Garrahan. Most commonly used metrics are shown.[8] BG, blood glucose; CGM, continuous glucose monitor; COVID, coronavirus disease; CV, coefficient of variation; ICU, intensive care unit; SD, standard deviation; TAR, time above range; TBR, time below range; TIR, time in range.

IU/(kg·d) in adults. These critical COVID patients (with ventilators, glucocorticoids, and many other comorbidities such as kidney transplant, obesity, hypertension, asthma) required much higher insulin infusions and yet the target glucose levels were hard to achieve. However, it is important to remark that, differing from the previous treatment based only on blood glucose measurements, hypoglycemic events were completely avoided. Moreover, all patients improved their times in range and were metabolically stabilized with the continuous monitoring. Thus, in addition to reducing physicians' exposure, the novel multiple monitoring platform allowed a significative improvement in glycemic control and safety of ICU patients. Regarding the isolated ambulatory patient, he has completed 199 days of remote monitoring without any adverse event (received samples: 96.37%; median glucose: 148.85 mg/dL; standard deviation: 51.15 mg/dL; number of calibrations: 202).

Based on this reported experience, the glucose management protocol for critical patients at Hospital Italiano has been updated, considering not only glucose levels but also its trends and rates of change.

Authors' Contributions

F.G. initiated and led the project. D.F., L.M., and N.R. designed the software in InsuMate under the supervision of F.G.. H.D.-B., R.S.-P., and E.F. reviewed and edited the article. J.G.-A., S.D., C.B., J.G., and M.L.-H. installed the CGM systems and incorporated the technology to the treatment routine in the COVID-19 ward. S.D., C.M.-M., and M.P. controlled the glycemic values under the supervision of E.S.-R., G.K., and L.G.

Author Disclosure Statement

No competing financial interests exist.

Funding Information

Research in this area is financed by the Argentine government (MINCYT BSAS28 COVID-Federal, PICT2017-3211, PIP0837, UNLP-I253) and Fundación Nuria.

References

1. Garg SK, ed.: Improving access with telehealth and CGM during COVID-19 and beyond. [Special Issue] Diabetes Technol Ther 2020;22:431–483.
2. Ushigome E, Yamazaki M, Hamaguchi M, et al.: Usefulness and safety of remote continuous glucose monitoring for a severe COVID-19 patient with diabetes. Diabetes Technol Ther 2020;22:1–3.
3. Shehav-Zaltzman G, Segal G, Konvalina N, et al.: Remote glucose monitoring of hospitalized, quarantined patients with diabetes and COVID-19. Diabetes Care 2020;43: e75–e76.
4. Reutrakul S, Genco M, Salinas H, et al.: Feasibility of inpatient continuous glucose monitoring during the COVID-19 pandemic: Early experience. Diabetes Care 2020;43:e137.
5. Beardsall K, Thomson L, Elleri D, et al.: Feasibility of automated insulin delivery guided by continuous glucose monitoring in preterm infants. Arch Dis Child Fetal Neonatal Ed 2020;105:279–284.
6. Singh LG, Satyarengga M, Marcano I, et al.: Reducing inpatient hypoglycemia in the general wards using real-time continuous glucose monitoring: The glucose telemetry system, a randomized clinical trial. Diabetes Care 2020;43: 2736–2743.
7. Nair BG, Dellinger EP, Flum DR, et al.: A pilot study of the feasibility and accuracy of inpatient continuous glucose monitoring. Diabetes Care 2020;43:e168–e169.
8. Battelino T, Danne T, Bergenstal RM, et al.: Clinical targets for continuous glucose monitoring data interpretation: recommendations from the international consensus on time in range. Diabetes Care 2019;42:1593–1603.

Address correspondence to:
Fabricio Garelli, PhD
Facultad de Ingeniería - UNLP
La Plata (1900)
Argentina

E-mail: fabricio@ing.unlp.edu.ar