Remote Glucose Monitoring of Hospitalized, Quarantined Patients With Diabetes and COVID-19

The rapid growth in diagnosed patients with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) led to national directives for hospital emergency preparedness. Sheba Medical Center, a government hospital in Israel, undertook emergency measures to expand the inpatient quarantine capacity and converted two general medical wards to isolation wards with enhanced ventilation support capabilities.

Diabetes is associated with increased severity, complications, and mortality from coronavirus disease 2019 (COVID-19) (1). The care of patients with diabetes under strict isolation poses significant competing challenges of maintaining adequate quality of care achieved by multiple daily glucose measurements while minimizing risk of staff exposure, highlighting timely blood glucose management for the COVID-19 outbreak as an urgent need (2). To prevent patient-staff transmission while maintaining standard of care for hospitalized patients with diabetes, a way to monitor glucose levels remotely—from outside the designated isolated rooms—is required.

We report our experience in activating five monitoring stations per department based on personal continuous glucose monitoring (CGM) systems. We used CGM transmitters (Guardian Connect, MMT-7820ME; Medtronic) connected to glucose sensors (Enlite, MMT-7020; Medtronic) transmitting glucose values every 5 min through Bluetooth connectivity to designated mobile devices that upload data to the web through a Guardian Connect application. Real-time glucose monitoring in the control, viral-free area was viewed continuously by the team using CareLink personal websites. To allow data visualization of several patients on one control screen, the CareLink personal websites were accessed via different browsers and minimized to allow a view of real-time continuous glucose levels of up to four patients on a single screen. Training for physicians and nurses was provided by trained staff from the hospital’s Division of Endocrinology, Diabetes and Metabolism. Teams were also provided with educational material and designated short videos for weekly replacement of sensors and instructions for timely calibrations. Calibrations were performed twice daily.

The request for remote glucose monitoring was made by the hospital on 18 March, and all monitoring stations were fully operational the following day. The first subjects who completed a week of remote glucose monitoring were one patient with type 1 diabetes on continuous subcutaneous insulin infusion and three patients with type 2 diabetes on a basal-bolus insulin regimen. Mean ± SD daily glucose measurements decreased from 3.75 ± 0.86 to 1.94 ± 0.31 with remote CGM (P = 0.005), with significant improvement in mean glucose levels from 258.2 ± 25.3 to 169.3 ± 7.9 mg/dL, respectively, P = 0.0006. Patient characteristics and glucose management parameters are detailed in Table 1. The main challenges included training alternating teams with the calibration procedure and cost. The analysis and report of the data were approved by the Institutional Review Board of Sheba Medical Center.

In summary, converting a personal CGM system originally designed for diabetes self-management to team-based, real-time remote glucose monitoring offers a novel tool for inpatient diabetes control in COVID-19 isolation facilities. Such a solution in addition to ongoing remotely monitored clinical parameters (such as pulse rate, electrocardiogram, and oxygen saturation) adds to quality of diabetes care while
minimizing risk of staff exposure and burden.

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Author Contributions. G.S.-Z. and A.T. initiated the project. G.S.-Z. and G.S. installed the CGM systems and incorporated the technology to the treatment routine in the COVID-19 ward. N.K. trained the treating teams and researched the data. A.T. researched the data and drafted the manuscript. All authors reviewed and edited the manuscript. A.T. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

References
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| Table 1—Characteristics of patients with COVID-19 and diabetes remotely managed with CGM |
|---------------------------------------------|-------|-------|-------|-------|
|                                             | Patient 1 | Patient 2 | Patient 3 | Patient 4 |
| Age (years)                                 | 26     | 63     | 76     | 82     |
| Sex                                         | F      | F      | M      | M      |
| Diabetes type                               | Type 1 | Type 2 | Newly diagnosed type 2 | Type 2 |
| COVID-19 severity                           | Mild   | Moderate | Severe | Severe |
| Need for oxygen support                     | Room air | Oxygen 4 L/min | Ventilator | High-flow oxygen |
| Additional comorbidities                    | None   | Ischemic CVA, HTN | HTN, NAFLD, CKD, hypothyroidism | HTN and dyslipidemia status post mechanical AVR, osteoporosis, past smoker |
| Diabetes treatment                          | CSII   | MDI    | MDI    | MDI    |
| Glucose management before CGM              |        |        |        |        |
| Mean blood glucose tests per day            | 4.7    | 2.8    | 3.75   | 3.0    |
| Mean ± SD blood glucose (mg/dL)             | 127 ± 33 | 382 ± 188 | 192 ± 79 | 183 ± 14 |
| Glucose management with remote real-time CGM|        |        |        |        |
| Mean blood glucose tests per day            | 2.3    | 1.5    | 1.8    | 2.1    |
| Mean ± SD blood glucose (mg/dL)             | 127 ± 32 | 200 ± 54 | 168 ± 63 | 145 ± 45 |
| Time with transmitted data (%)              | 96.3   | 72.3   | 90.8   | 97.2   |
| TIR >250 mg/dL (%)                          | 0.0    | 13.2   | 13.7   | 1.7    |
| TIR 180–250 mg/dL (%)                       | 5.7    | 56.7   | 29.0   | 14.2   |
| TIR 110–180 mg/dL (%)                       | 60.4   | 30.0   | 32.7   | 64.2   |
| TIR 70–110 mg/dL (%)                        | 33.1   | 0.1    | 23.9   | 12.6   |
| TIR <70 mg/dL (%)                           | 0.8    | 0.0    | 0.7    | 5.6    |
| TIR <54 mg/dL (%)                           | 0.0    | 0.0    | 0.0    | 1.7    |

AVR, aortic valve replacement; CSII, continuous subcutaneous insulin infusion; CVA, cerebrovascular accident; HTN, hypertension; MDI, multiple daily injections of insulin; NAFLD, nonalcoholic fatty liver disease; TIR, time in range.