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Glucose Homeostasis during Ramadan Fasting: First Case Series Illustrated by Flash Glucose Monitoring and Ambulatory Glucose Profiling

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Abstract

Background: The impact of fasting during the month of Ramadan, practiced by adult Muslims, on glucose homeostasis has attracted much attention recently with view to understanding the metabolic price of fasting and to help plan rational management. The flash glucose monitoring (FGM) expressed as ambulatory glucose profiles (AGP) provides a minimally invasive yet comprehensive insight into blood glucose (BG) changes in relationship to various physiological and behavioral factors. **Objectives:** To investigate the BG homeostasis during Ramadan fasting in a group of individuals with different states of glucose tolerance. **Methods:** Eight individuals who were fasting during Ramadan were studied by FGM using the Abbott's FreeStyle® Libre™ system. They included individuals with normal glucose tolerance during pregnancy (1), prediabetes (2), post-bariatric hypoglycemia (1) and type 2 diabetes mellitus (4). **Results:** In the normal pregnancy AGP's fluctuated minimally around meals with some asymptomatic low BG readings on prolonged fasting. In those with prediabetes, most of the daytime BG were within normal but there was a minimal post-prandial rises and some asymptomatic lower readings on prolonged fasting too. In the case of the patient with history of post-bariatric hypoglycemia, daytime fasting periods had perfectly stable normal BG. However, marked early postprandial hyperglycemia occurred in the evening followed by a short-lived symptomatic hypoglycemia. In the 4 patients with diabetes, AGP showed high glucose exposure, wide variation and marked instability after both traditional meals of dawn time (*Suhor*) and sunset (*Iftar*) particularly in the later. A variably slow downward trend throughout the day was observed. The differences in the AGP's reflected both biological and behavioral differences between patients within the general picture. AGP's before, during and after Ramadan in 3 patients revealed distinctly-different profiles reflecting the Middle Eastern meal pattern, Ramadan meal pattern and *Eid* feasting respectively. For patients these findings were discussed with them and used to plan glycemic management. **Conclusions:** This is the first comprehensive demonstration of glucose changes during Ramadan fasting using AGP. The visually illustrated data give insights into glucoses homeostasis in diabetes and related disorders throughout whole day of Ramadan. This may help inform therapeutic decisions on individual basis and help plan future studies.

Key words: Continuous glucose monitoring (CGM) systems, Hyperglycemia, Hypoglycemia, Ramadan, Fasting and feasting, FreeStyle® Libre™ , Flash glucose monitoring, Ethnicity and Diabetes.

Introduction

Daytime fasting is observed by healthy Muslim adults for 29-30 days every year during Ramadan, the 9th month of the lunar calendar (1). Those who suffer certain acute and chronic medical conditions such as diabetes are exempted from fasting (1), however, two large epidemiologic studies have confirmed that many patients with diabetes do observe the fast (2,3). On occasions, they may even insist on fasting against clearly stated advice from physicians and religious scholars (4).

Ramadan fasting produces repeated cycles of two contrasting metabolic environments resulting from the strict "total fasting" in the day time and liberal "feasting" during the night time (1). Although hypoglycemia during the day of Ramadan remains the most feared complication of diabetes, hyperglycemia in the evening time should not be treated with any degree of complacency. Understanding the changes in glucose homeostasis during Ramadan is vital scientific basis for recommendations on therapeutic strategies by physicians. It is also needed to provide convincing arguments to help educate patients, so that they can readily understand and confidently accept these medical recommendations (5,6).

Monitoring of blood glucose is essential and is uniformly-recommended. However, there is some resistance to performing monitoring tests in general and during Ramadan fasting in particular as some people think this may interfere with the fasting act. The newer minimally invasive flash glucose monitoring (FGM) system expressed as ambulatory glucose profile (AGP) can give comprehensive insights into changes in glucose homeostasis in the form of a series of dashboards of visual nature (7-8). With these features, its place in clinical practice is getting more established in guidance by professional groups and experts (9-11).A positive impact on glycemic control associated with their usage in both type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) has been reported (12) and their use seems to be expanding in emerging markets (13). Impact of socializing, fasting and feasting outside the month of Ramadan was recently demonstrated in a detailed report in this journal albeit on a single case(14).We are not aware of the use of AGP during the month of Ramadan itself.

This is the first report using FGM and AGP to illustrate the changes in blood glucose levels during the month of Ramadan. A series of individuals with diabetes and related metabolic conditions are presented to explain the FGM technology and AGP concept, and demonstrate the calculations of the AGP metrics and their interpretations.

Patients and methods

Settings

This is a clinical case series from The Center for Diabetes and Endocrinology at Sheikh Khalifa Medical City, Abu Dhabi, UAE. It is a retrospective report of clinical observations stored electronically. No experimental maneuvers, procedures or medications were involved. Prior formal approval by the Institutional Review Board is not normally required in our institution for single case reports or small case series encountered during clinical care or training. All subjects verbally consented for their data to be included in this report prior to drafting of the manuscript.

Subjects

The case series include 8 individuals (3 clinic staff and 5 patients). The demographic and clinical characteristics of the participants are given in table 1. For the staff (subjects 1-3), data were captured as part of a staff training program that occurred during fasting month. For the patients (subjects 4-8), data were collected during the course of their normal diabetes care as deemed appropriate by the physician (SAB) and the diabetes educators (MK and MH) involved.

Data were captured during the routine clinic visit to uploaded, interpreted and acted upon as appropriate for the patients care and all changes made are agreed with the patients and documented in their electronic records on the same day of the encounter.

Table 1. Demographic and clinical characteristics of the case series. Subjects 1-3 are staff and subjects 4-8 are patients attending for normal diabetes care.

Case	Age	Sex	Wt. (kg)	Ht. (cm)	BMI (kg/m^2)	HbA1c	Diagnosis	Current treatment	Notes
1	32	F	82	168	31.2	4.8%	Normal pregnancy (G3, 23/40)	Nil	No GDM in previous pregnancies.
2	47	F	60	160	23.4	5.7%	Pre-diabetes; non-obese, Hypertension	Bisoprolol 2.5 mgs QD	Cured Conn's syndrome
3	43	F	85	157	34.5	5.8%	Pre-diabetes, obese; steroid-induced DM in remission	Nil	Off steroid for 6 months, was on metformin
4	56	F	69	156	28.4	5.5%	Post-bariatric hypoglycemia	Octreotide (once); was on alpha-glucosidase inhibitor recently	Total weight loss 60 kg. No prior DM
5	73	M	102	174	33.7	8.2%	T2DM, Morbid obesity, OSA, Neuropathy, BKA,	Glargine, Dapagliflozin 10mg, Dulaglutide 1.5mg QW, Gliclazide MR 60 mgs, Metformin 1g BID	Wheel chair bound, excessive socializing,
6	63	F	85	156	34.9	7.4%	T2DM, CKD (eGFR=34)	Degludec 36 U + Repaglinide 2 mg BD	Wheel chair-bound, mostly house-bound.
7	61	M	66	165	25.3	7.3%	T2DM, Post bariatric surgery,	Glargine 14 QD; Aspart 14 U QD; Linagliptin 5 mg QD	Poor compliance, excessive socializing,
8	44	M	148	180	45.6	12.5%	T2DM (poor control), post-renal transplant; eGFR=41	Degludec 80, Dulaglutide 1.5 mg; QW;	Self-employed busy business man; very complacent regarding diabetes control,

A brief description of FGM and AGP

The FGM system (FreeStyle® Libre™ , Abbott Diabetes Care, Alameda, CA) was used in this series. It includes a very tiny glucose sensor (0.2 inches in length, about the thickness of a hair) worn under the skin and connected to a water resistant, plastic on-body patch the size of a medium sized coin. The sensor remains inserted for 14 days and does not require finger stick calibrations. After putting it on the upper arm and waiting one hour, it immediately begins reading glucose and trend information. FreeStyle® Libre™ is approved for dosing insulin except in three cases when a finger stick is recommended: hypoglycemic, rapidly changing glucose and when symptoms don't match the system's readings. The user takes a touch screen reader device, hold it near (within 1.5 inches) the sensor patch, and wait for it to beep. In less than a second, they can see their real-time glucose value, a glucose trend arrow, and a trend graph showing the last eight hours of data. The reader device displays reports on its screen that can be downloaded to personal computers and data can be saved for further examination as previously described (7-11).

Acquisition, synthesis and presentation of data

The theoretical basis, definitions and calculations of the AGP metrics are well described in a recent report by Distiller and colleagues (13). Throughout the present report, individual subjects are referred to uniformly by their serial number 1-8 in text, tables and figures. Data were available before, during and after Ramadan on 3 patients (subjects 5-7), and for 14 days during Ramadan for the remaining 2 patients (subjects 4 & 8). Data on staff (subjects 1-3) were available for 6-12 days during Ramadan fasting only (sensors fell off). After use, sensor data were collected and uploaded for AGP reporting. For the purpose of this report, all records were re-examined for uniformity jointly by all authors.

Data were examined for specific periods in relationship to Ramadan fasting using the comprehensive default setting of the manufacturer's software available for clinical us and were saved for further analysis. AGP during the month of Ramadan in the various metabolic conditions are shown in figure 1. The two parallel horizontal solid lines delineate the target blood glucose range set by the diabetes care providers for the patients on individual basis. The dark blue curve defines the median, dark blue area the 25th-75th centiles ranges and the light blue defines the 10th-90th centiles range. Note the AGP metrics and the time patterns during the day and night in different individuals and particularly between diabetic and non-diabetic patients. Representative single day CGM-type records are presented. "Glucose profile insights" representing readily reported metrics by the software were captured.

Recommended AGP metrics (exposure and instability) were manually-calculated. Exposure and instability were specifically conceptualized for Ramadan (i.e. exposure in the day fasting time vs. exposure night non-fasting time; instability during the day, around *iftar* and around *suhor*). AGP and CGM-type curves in three diabetic patients only (subjects 5-7) before, during and after Ramadan are shown in figures 4 and 5. Glucose variability were unmistakably represented graphically and therefore we have not translated them into numerical metrics (such as IQ ranges) taking in consideration the small number of subjects and the wide variation at different times. In general, results are presented and discussed in narrative or numerical terms as seemed appropriate. Statistical significance of differences were tested using non-parametric statistics.

Results

All patients and staff tolerated the study well. There was a high concordance (R^2=0.86) between the laboratory and estimated HbA1c in all but one subject (Figure 1).

AGP during Ramadan: An Overview

In the pregnant woman with established normal glucose tolerance, BG fluctuated within targets (71% of the time), during fasting and around meals with no rise other than 1% of the time but there was asymptomatic lower readings (28% of the time) mostly on prolonged fasting (Figures 2,3).

In the 2 individuals with pre-diabetes (Figures 2,3), BG remained within targets during 80-90% of the time. There was a short-lived minimal post-prandial rises just above the target range (during 2-3% only of the time). Some asymptomatic lower readings on prolonged fasting were observed (7-18% of the time, mostly in the late afternoon i.e. end of the fasting period).

In the case of the post-bariatric patient with history of recurrent and occasionally severe postprandial hypoglycemia, day time fasting periods were perfectly normal (74% of the whole time), however, an early postprandial hyperglycemia occurred after meals (spanning 22% of the time) followed by marked hypoglycemia was observed consistently with every evening meal (Figure 2; Table 2).

In the 4 patients with diabetes (Figure 2; Table 2), AGP levels were higher initially than the non-diabetic individuals and they and hyperglycemia worsened after the two traditional meals of dawn (*Suhor*) and sunset (*Iftar*) at a widely variable level and duration of duration. However, there was a downward trend throughout the day. This pattern was evident in both the AGP (Figure 1) and the selected representative single day curves (CGM-type pattern shown in Figure 3).

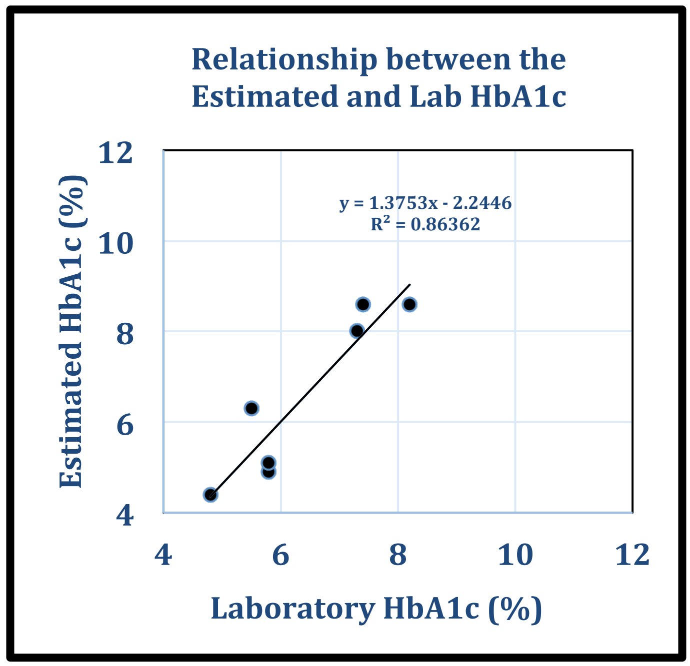

Figure 1. The relationship between the laboratory-measured HbA1c and AGP-estimated HbA1c in 7 out of the 8 study subjects. Subject 8 was excluded from R2 calculation being an extreme outlier (estimated 6.3% vs. laboratory12.5%).

"Ramadan-Specific" AGP metrics

The individual measures of glucose exposure and instability are presented in table 2 and 3 and figures 1 and 2. The glucose exposure measured as the mean (SD) AUC for the whole day, fasting periods and evening non-fasting periods were 142(49) mg/dl/hr, 133(46) and 156(61) mg/dl/hr respectively (Table 3)

Table 2. "Glucose Pattern Insights" as seen in the clinical reports by the manufacturer's software. Column 1 defines subjects; columns 2-5show the likelihood of hypoglycemia (upper), variation of the mean (middle) and variability below the mean (lower) in relationship to 5 time intervals scored in colors coding for high (red), moderate (orange) and low (green). Column 6 gives the actual time spent below targets in minutes (upper), mean blood glucose (middle) and number of events below glucose target (lower). Column 7 shows the percentage of time below target (upper), above target (middle) and within target (lower).

Times	03-08hr	08-12hr	12-18hr	18-22hr	22-03hr	Time spent below target (minutes)	Percentage of time in personalized targets
SN	Likelihood of hypoglycemia						Below target
1	Red	Orange	Red	Red	Orange	277	28%
2	Red	Orange	Red	Red	Orange	151	18%
3	Green	Green	Orange	Red	Green	111	7%
4	Green	Green	Green	Orange	Red	47	4%
5	Green	Green	Green	Orange	Green	0	0
6	Green	Green	Green	Green	Green	0	0
7	Red	Red	Green	Orange	Green	213	7%
8	Orange	Red	Red	Red	Orange	203	17%
SN	Variation of mean from target glucose					Mean BG (mg/dl)	Above target
1	Green	Green	Green	Green	Green	81	1%
2	Green	Green	Green	Green	Green	94	2%
3	Green	Green	Green	Green	Green	101	3%
4	Green	Green	Green	Red	Green	134	22%
5	Red	Orange	Orange	Orange	Orange	199	79%
6	Orange	Orange	Orange	Green	Red	199	82%
7	Green	Green	Green	Red	Red	184	37%
8	Green	Green	Green	Green	Green	135	36%
SN	Variability below the mean BG					Events below target (N)	Within target
1	Green	Green	Green	Green	Green	11	71%
2	Green	Green	Green	Orange	Green	11	80%
3	Green	Green	Green	Orange	Green	8	90%
4	Green	Green	Green	Red	Green	5	74%
5	Orange	Orange	Orange	Orange	Orange	0	21%
6	Orange	Green	Green	Orange	Red	0	18%
7	Orange	Orange	Orange	Red	Red	9	56%
8	Red	Orange	Green	Orange	Orange	13	47%

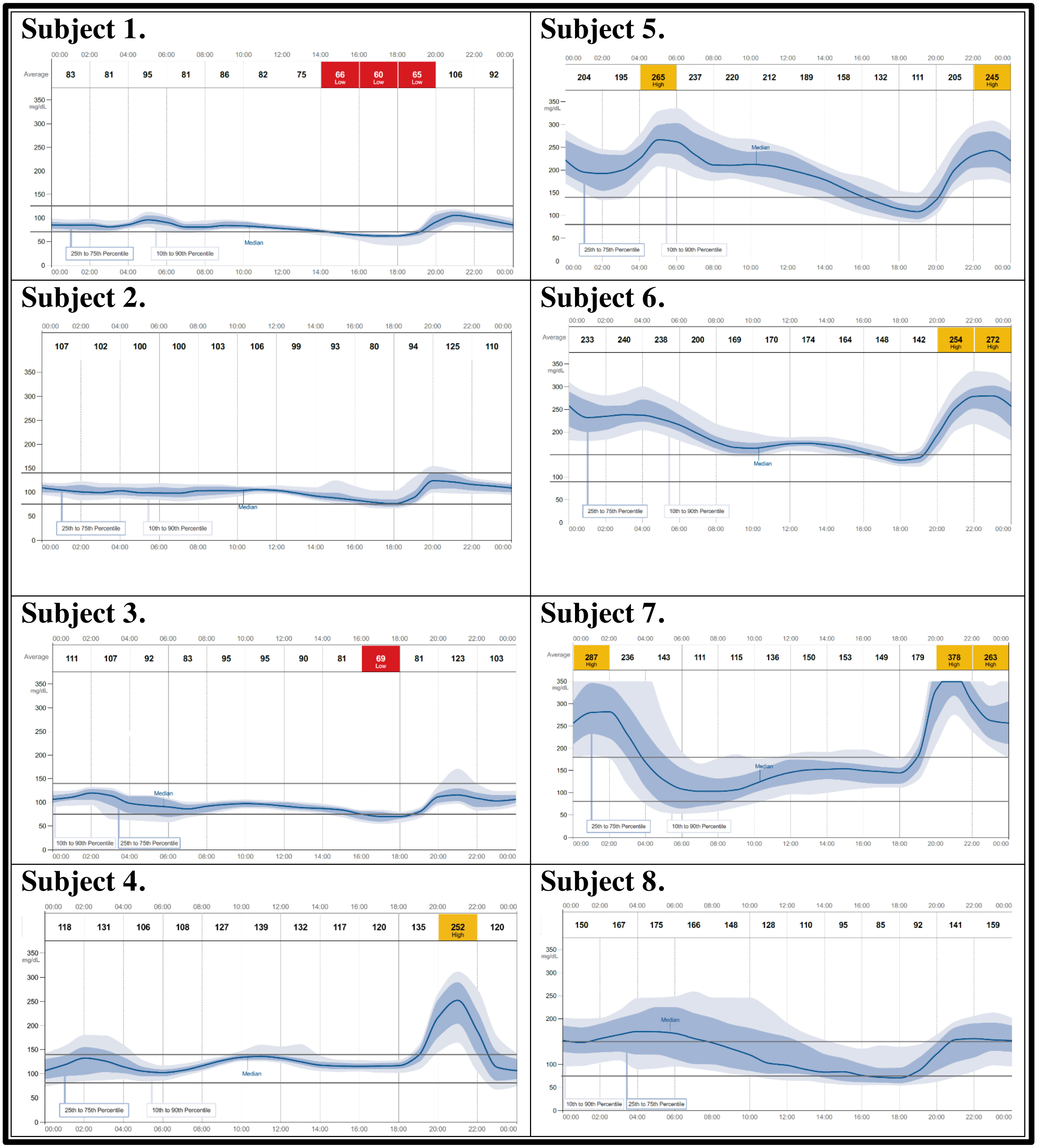

Figure 2. The AGP during the month of Ramadan in various metabolic conditions (subjects 1-8 corresponding to table 1 and text).

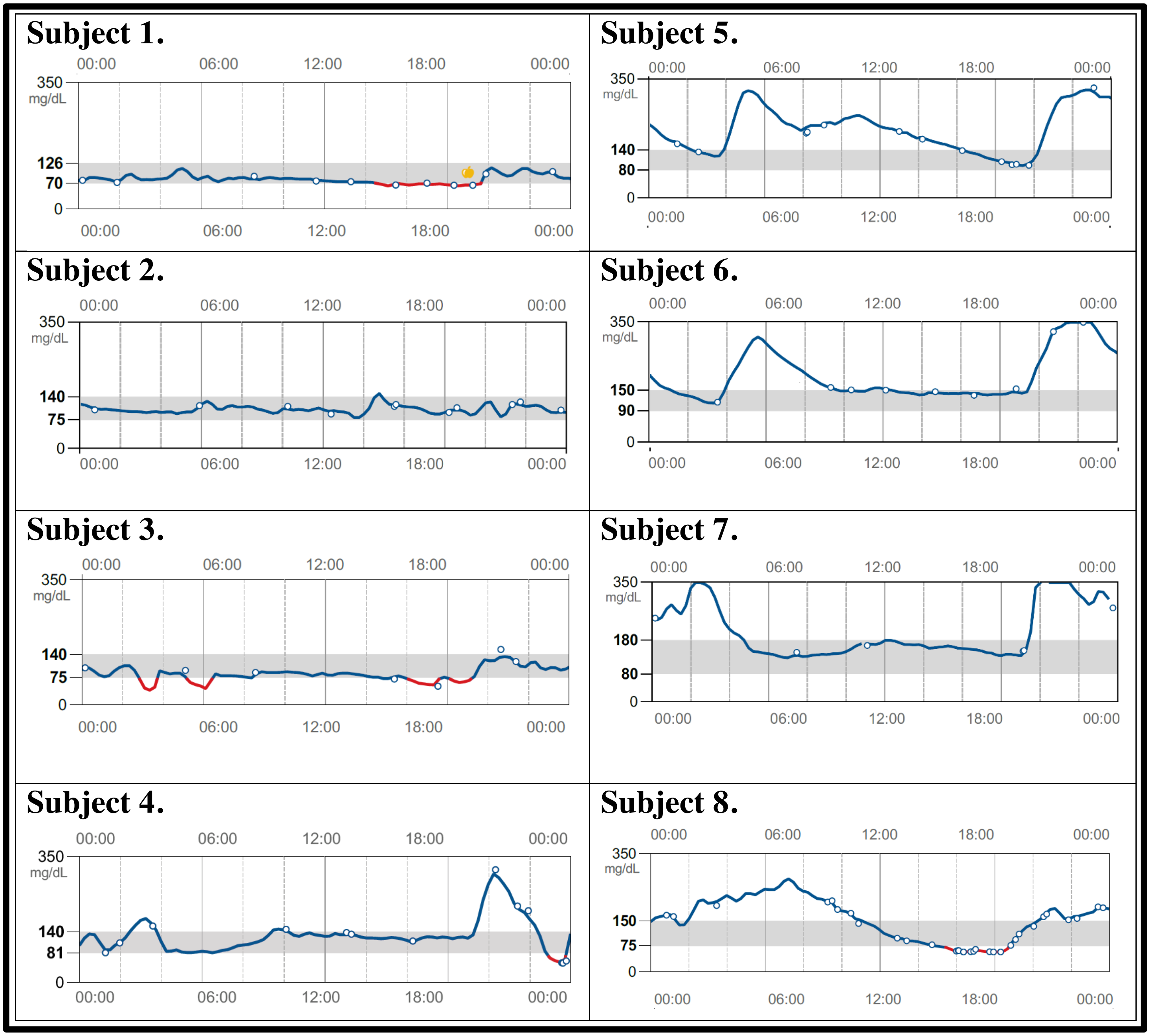

Figure 3. The blood glucose levels during a typical day in various metabolic conditions. The light blue rectangle shows the target blood glucose range set by the diabetes care providers for the patients on individual basis (See text for further details).

AGP before, during and after Ramadan

Comparisons of AGP's before, during and after Ramadan for three patients are presented in figures 4 and 5. These revealed distinctly different profiles reflecting the commonly seen Middle Eastern meal pattern, Ramadan meal pattern and post Ramadan *Eid* feasting respectively. This pattern was evident in both the AGP pattern (Figure 4) and AGP metrics (data not reported) and the clearly exemplified by the selected single day (CGM-type of pattern (Figure 5)

Table 3. Data on two calculated AGP metrics (exposure and stability): Glucose exposure in the whole day, during day time and night time are expressed as area under curve (AUC) for 24 hours, fasting period and non-fasting periods respectively. Glucose (in) stability is calculated for the fasting time and around the main two traditional meals.

Subject	Glucose exposure (AUC) (mg/dl/hr)			Glucose (in)stability (mg/dl/hr)		
	Total	Day time 04-19 hours	Night time 19-04 hours	Fasting time (08-18hr)	Around *Iftar* (19-22 hr)	Around *Suhor* (03-06hr)
1	81	76	88	8	28	14
2	102	99	105	5	23	4
3	94	90	101	8	27	10
4	134	123	150	12	66	19
5	197	191	204	26	40	58
6	200	187	219	16	59	5
7	191	142	260	18	115	72
8	135	137	134	20	28	13
Median	**134.5**	**130***	**142***	**14****	**34****	**13.5**

Using Wilcoxon Signed-Rank Test: * differences is statistically significant between day time vs. night time exposure (p<0.05) and **differences is statistically significant for peri-*iftar* instability compared with day time instability (p<0.01) but not for peri-*iftar* instability vs. peri-*suhor* instability (NS).

Discussion

Self-monitoring of blood glucose (SMBG) is essential to optimize glycemic control in diabetes mellitus (15,16). Several methods are now available that include measuring of capillary blood glucose using conventional glucose meters and measuring of interstitial fluid glucose levels by continuous glucose monitoring (CGM) systems (17). CGM provide a semi-continuous information about glucose levels, which identifies fluctuations that would not have been identified with conventional self-monitoring.

Two types of CGM systems can be defined: retrospective systems and real-time systems. Real-time systems continuously provide the actual glucose concentration on a display. AGP is a novel way of assessing glycemic levels on a 24 hour basis, through a minimally invasive method making it particularly relevant during Ramadan where there a contrasting blood glucose levels in the day and night. AGP was originally developed by the International Diabetes Center, USA as a statistical and visual representation of glycemic exposure, variability, and hypoglycemic risk. AGP is presented in a series of screens that allows clinicians and patients to readily identify glucose patterns and address areas of highest clinical concern so that lifestyle and insulin therapy can be adjusted appropriately (7-11).

Use of such a method is expanding in many parts of the world including our own speeded by patients' demand for painless monitoring methods. Studies are therefore needed to inform optimal adoption and use to benefit maximally from its features rather than simply pain-free SMBG method. Management of diabetes during Ramadan is a prime example of ethnically sensitive diabetes care (1,5,6). The fact that patients have been fasting for so many years may give them a false sense of security and ill-founded confidence that they will come to no harm.

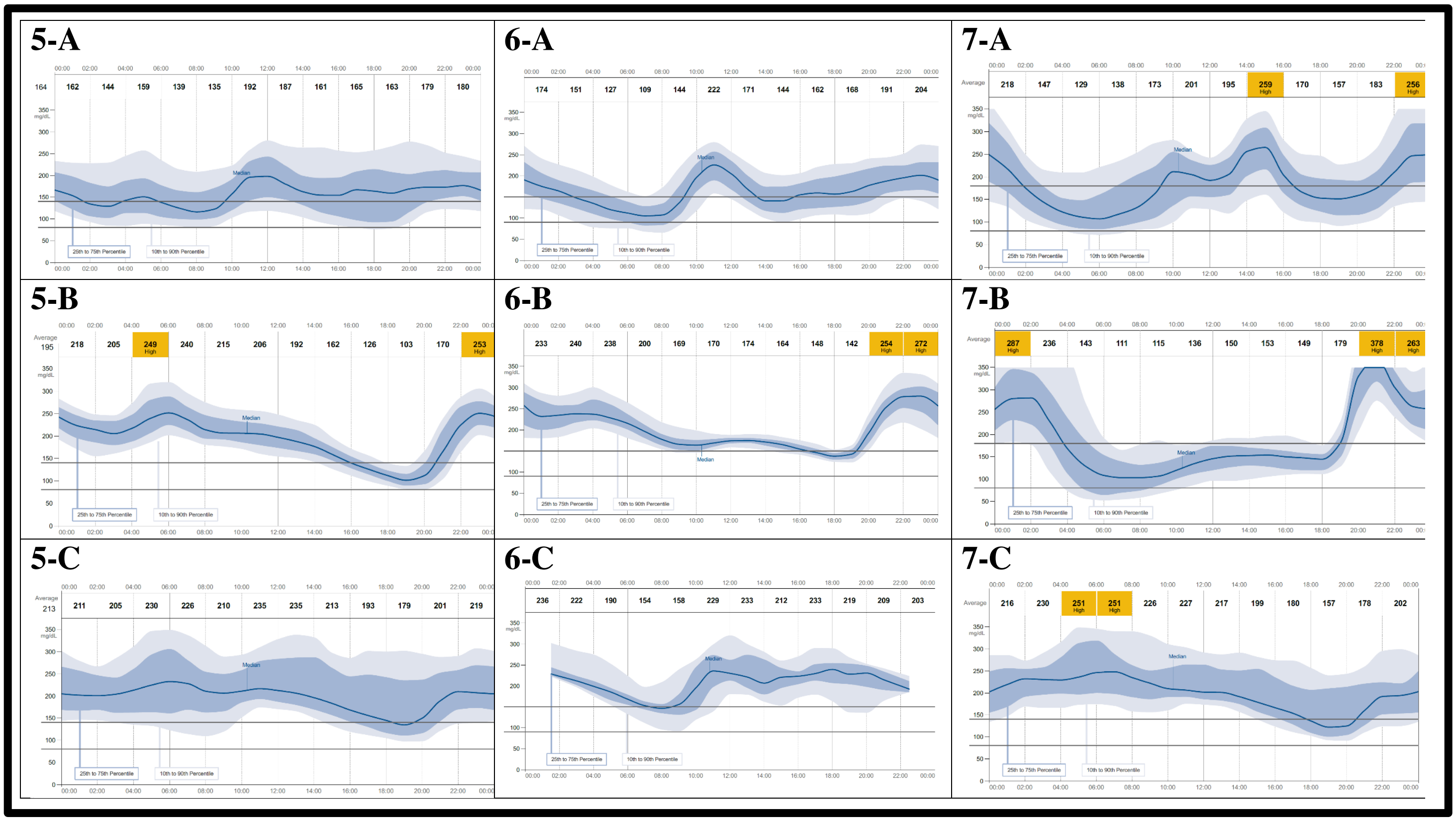

Figure 4. The AGP's before (A1-A3), during (B1-B3) and after (C1-C3) the month of Ramadan respectively in three patients with diabetes (Subjects 5-7 in Tables 1,2 and figures 1,2). The A's AGP show the typical pre-Ramadan usual Middle Eastern dietary pattern, B's AGPs depict the typical Ramadan pattern and C's AGPs represent the post-Ramadan 6 days of Eid feast.

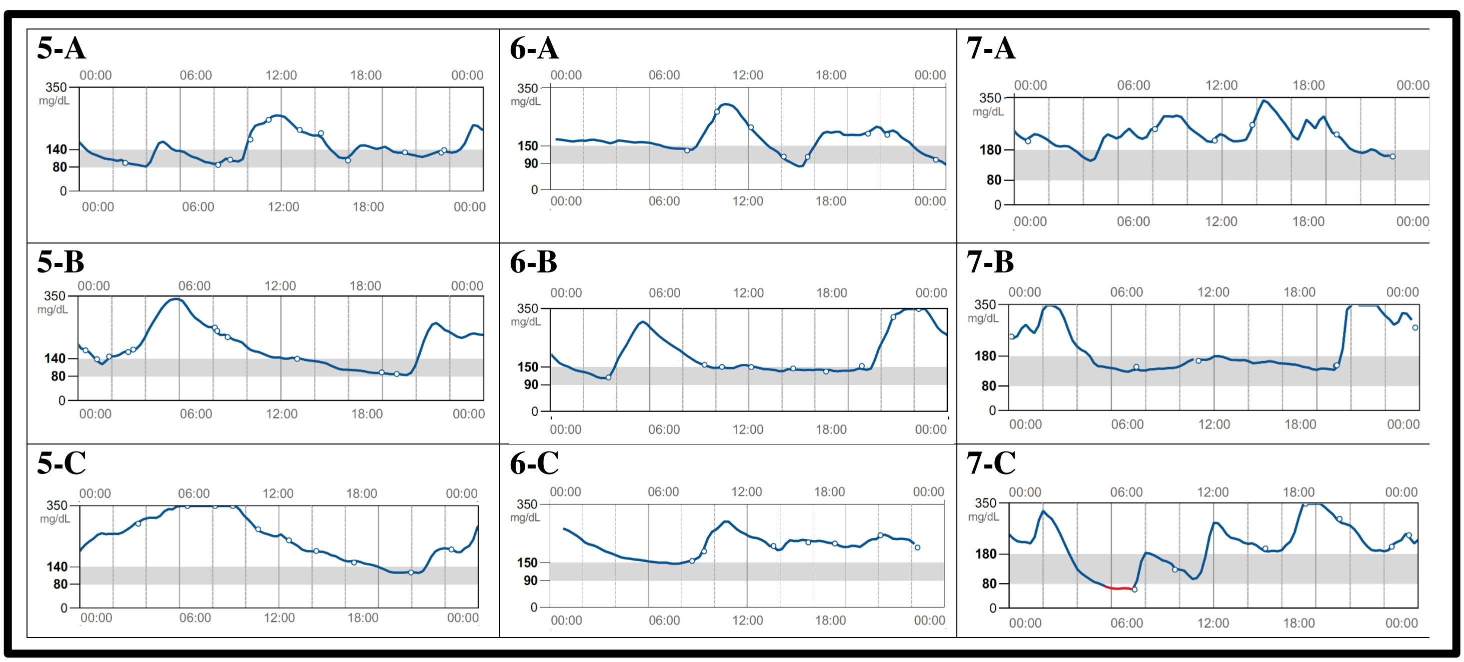

Figure 5. This panel demonstrates the corresponding single "typical" day pattern before (A1-A3), during (B1-B3) and after (C1-C3) the month of Ramadan respectively in the same three patients 5-7 in described table 1; (see text).

SMBG during both the abstinence day time and the liberal evening hours in Ramadan has been recommended for all patients on insulin therapy or on insulin-secreting agents to safe guard against both hypo- and hyperglycemia (5,6). Most of the large Ramadan studies were based mostly on SMBG and only the smaller studies used on continuous glucose monitoring (CGM) technology (18-22).

To our knowledge, this is the first report that assesses BG fluctuation during Ramadan fasting using FGM methodology expressed as AGP. The ready access to real time blood glucose levels, trends and the lack of any prohibiting cost or pain based-issue once the system is acquired is self-evident (13,23). In addition, patients (though this remains a minority) refrain from performing finger bricking on the basis it may interfere with the fasting act. Therefore, FGM comes handy to help resolve this conflict over and above its unlimited monitoring times making this case series particularly relevant to clinical practice in Ramadan. This case series was collated by shear serendipity. The authors were examining data from normal clinical practice and education and wished to understand the effect of fasting on diurnal glucose patterns and overall glycemic control. In addition to its novelty, this real world experience, albeit involving only a small number of subjects, comprehensively illustrated details captured on all aspects of glucose homeostasis make it particularly valuable. Since this use of this technology is expanding very rapidly, we should miss no any opportunities of learning about its advantages and limitations in the real world (12-14). A recent study from Germany highlighted how physicians valued the visual presentation of the glucose homeostasis data as AGP and set an example of similar studies in other regions (23). Whereas previous studies focused on presenting day and night time AGP metrics to evaluate the specific risk of hypoglycemia in these time periods, in the present study we conceptualized newer ways to calculate some Ramadan-specific AGP metrics such as “fasting versus non fasting” exposure and “instability in the day time (fasting) and around main meals (feasting)” to enrich methods of AGP analysis in diverse cultural contexts. Future studies may be able to use the same and either concur or contrast with our experience.

Our series had a variety of subjects with different grades of metabolic derangements. In the pregnant woman, event at this stage of pregnancy (23 weeks), the hypoglycemia may hint to a degree of effect typical of impact of pregnancy on carbohydrate tolerance in in obese with a family history of diabetes (24). The changes seen in the two patients with prediabetes are classical of this condition particularly the mild postprandial rises but the day time fasting may be particularly beneficial if overeating is avoided at night. Probably, a most interesting finding was the AGP in the patient with known history of post-bariatric hypoglycemia; she was totally free from hypoglycemia during the daytime. However, immediately after main evening meal in the evening, a marked hyperglycemia was followed by hypoglycemia. This is reassuring, as fasting in such patients does not pose increased risk of hypoglycemia in the daytime in contrast to the spontaneous hypoglycemia due to insulinomas that usually preclude fasting (25). Adhering to the recommended dietary modification and pharmacological therapy targeting at the postprandial state of the traditionally large meal can not be overemphasized (26).

Pragmatically, the 4 patients with diabetes remain the most import subgroup. They presented a wide spectrum of essentially the same AGP’s. The most consistent feature is the marked hypergylemia after the two meals and the downward trend during the day time between *Suhor* and *Iftar* as shown in figures 2,3. However, the wide 10-90th deciles ranges particularly in the 3 men indicate the variation in food consumption whiles socializing at night. The female patients (Subject 6) is reportedly mostly house-bound and she does not have much variation in her social life as supported by the narrow glucose variability throughout the month of Ramadan. It is widely known anecdote that the first evening meal (*iftar*) is by far larger than the predawn meal (*suhor)*. The illustration and metrics reported here does not support this; medication should clearly be carefully adjusted against glucose exposure at different times of the day (5,6).

The present paper is limited by the small number of subjects. This restrictions generalizing the conclusions at this stage. However, it is heavily illustrated akin to a clinical and technical vignette to convey a clear educational messages to stimulate discussions. Obviously, we do not suggest that fasting patients should be changed to FGM outside its usual recommendations (9-11), however, we cannot ignore the fact that use of this technology is rapidly expanding in regions where non-finger pricking methods may appeal to patients and it is timely that we learn about all of its aspects rapidly to acquire and evaluate our perceptions and clinical experiences (12-14,23).

In conclusion, this is first report of AGP by FGM using the FreeStyle® Libre™ during Ramadan. It aimed to enhanceunderstanding and expandfamiliarity with the concept and technology in general and with its potential usability in special circumstances. Several educational points were learned giving further insights into glucose homeostasis during fasting in various states of glucose tolerance. We seized the opportunity to experiment with previously reported (day and night) metrics and to propose the new set of "Ramadan-specific metrics". Larger studies are needed to elucidate further the metabolic changes in younger patients who may wish to fast, all type 1 diabetes of all ages and even patients with increased risks of hypoglycemia by virtue of hypoglycemic unawareness, renal impairment or liver disease. In clinical practice, the visually illustrated reports can help physicians develop rational regimens and the real time monitoring facility can impart more confidents and sense of security on patients. However, for research purposes, we think that further updates in the operating software may be urgently needed to facilitate research conducted in the real world by busy clinicians. Applying the methods used in a recent study (13) was not possible as data in the clinical version of the software could only be exported as a pdf type with other restriction making attempts of further analysis prohibitively labor-intensive or impossible. If research-oriented software is made available to front line clinicians, such studies should help define the most appropriate therapeutic regimens to avoid both hypo and hyperglycemia during fasting being a central goal for management for diabetes during Ramadan fasting.

Disclosures

Conflicts of interests: None

Funding: No funding received. Some of the meters and sensors were provided by the vendors for use by patients and staff experience as part of "pre-ordering evaluation exercise", a usual business practice conducted by The Purchasing Department, SKMC, Abu Dhabi.

Contributions: SAB conceived and developed paper's concept and drafted the manuscript. MK and MH contributed to the data collection and analysis during the patients' care and staff training.

Disclaimer: Neither the manufacturer of the FreeStyle® Libre™ FGM system (Abbott Diabetes Care, Alameda, CA) nor the local trading agent were involved in this case series.

References

1. Beshyah SA, Fathalla W, Saleh A, Al-Kaddour A, Noshi M, Al Hatheethi H, et al. Ramadan fasting and the medical patient: An overview for clinicians. Ibnosina J Med BS 2010;2(5): 240-57.
2. Salti I, Benard E, Detournay B, Bianchi-Biscay M, Le Brigand C, Voinet C, et al. A population-based study of diabetes and its characteristics during the fasting month of Ramadan in 13 countries: results of the epidemiology of diabetes and Ramadan 1422/2001 (EPIDIAR) study. Diabetes Care 2004;27:2306-11.
3. Babineaux SM, Toaima D, Boye KS, Zagar A, Tahbaz A, Jabbar A, et al. Multi-country retrospective observational study of the management and outcomes of patients with type 2 diabetes during Ramadan in 2010 (CREED). Diabet Med 2015;32:819-28.
4. Beshyah SA. Fasting during the month of Ramadan for people with diabetes: Medicine and Fiqh united at last. Ibnosina J Med BS 2009;1:58-60.
5. Ali S, Davies MJ, Brady EM, Gray LJ, Khunti K, Beshyah SA, et al. Guidelines for managing diabetes in Ramadan. Diabet Med 2016;33(10):1315-29
6. International Diabetes Federation and the DAR International Alliance. Diabetes and Ramadan: Practical Guidelines. Brussels, Belgium: International Diabetes Federation, 2016. www.idf.org/guidelines/diabetes-in-ramadan and www.daralliance.org.
7. Abbott Diabetes Care. For Health Professionals (http://abbottnextfrontier.com/Information) available at http://www.freestylelibre.co.uk Accessed on 6th May 2016.
8. Bailey T, Bode BW, Christiansen MP, Klaff LJ, Alva S. The performance and usability of a factory-calibrated flash glucose monitoring system. Diabetes Technol Ther 2015;17(11):787-94.
9. Bergenstal RM, Ahmann AJ, Bailey T, Beck RW, Bissen J, Buckingham B. Recommendations for standardizing glucose reporting and analysis to optimize clinical decision making in diabetes: The ambulatory

glucose profile. J Diabetes Sci Technol 2013; 7(2): 562-78.
10. Kalra S, Gupta Y. Ambulatory glucose profile: Flash glucose monitoring. J Pak Med Assoc 2015;65(12):1360-2.
11. Hammond P. Interpreting the ambulatory glucose profile. Br J Diabetes 2016;16 (Suppl.1):S10-5
12. Ajjan RA, Abouglila K, Bellary S, Collier A, Franke B, Jude EB, et al. Sensor and software use for the glycemic management of insulin-treated type 1 and type 2 diabetes patients. Diab Vasc Dis Res 2016;13(3):211-9.
13. Distiller LA, Cranston I, Mazze R. First clinical experience with FreeStyle Libre Pro flash glucose monitoring (FGM): Characterizing glycemic control with ambulatory glucose profile (AGP) analysis in South Africa. J Diabetes Sci Technol 2016 May 5. pii: 1932296816648165. [Epub ahead of print]
14. Beshyah SA, Haddad M. Impact of socializing, fasting and feasting on day to day blood glucose profiles in diabetes elucidated by the FreeStyle® Libre™ System. Ibnosina J Med BS 2016; 8(8):114-9.
15. Inzucchi SE, Bergensta RM, Buse JB, Diamant M, Ferrannini E, Nauck M, et al. Management of hyperglycemia in type 2 diabetes: A patient-centered approach - Position statement of the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). Diabetes Care 2012;35(6):1364-79.
16. Mechanick JI, Camacho PM, Garber AJ, Garber JR, Pessah-Pollack R, Petak SM et al. American Association of Clinical Endocrinologists and American College of Endocrinology Protocol for Standardized Production of Clinical Practice Guidelines, Algorithms, and Checklists-2014 Update and the AACe G4G Program. Endocr Pract 2014;20(7):692-702.
17. Evans M. Current methods of assessing blood glucose control in diabetes. Br J Diabetes 2016;16(Suppl 1):S7-9
18. Bonakdaran SH, Khajeh-Dalouie M. The effects of fasting during Ramadan on glycemic excursions detected by continuous glucose monitoring system (CGMS) in patients with type 2 diabetes. Med J Malaysia 2011;66 (5):447-50.
19. Oueslati I, Ben Said R, Kammoun I, Haouat E, Ben Salem L, Turki Z, Ben Slama C. Continuous glucose monitoring in glimipiride plus metformin treated type 2 diabetic patients during the month of Ramadan. Tunis Med 2012;90(10):735-9.
20. Lessan N, Hannoun Z, Hasan H, Barakat MT. Glucose excursions and glycemic control during Ramadan fasting in diabetic patients: insights from continuous glucose monitoring (CGM). Diabetes Metab 2015;41(1):28-36.
21. Khalil AB, Beshyah SA, Abu Awad SM, Benbarka MM, Haddad M, Al-Hassan D, et al. Ramadan fasting in diabetes patients on insulin pump therapy augmented by continuous glucose monitoring: an observational real-life study. Diabetes Technol Ther 2012;14(9):813-8.
22. Kaplan W, Afandi B. Blood glucose fluctuation during Ramadan fasting in adolescents with type 1 diabetes: Findings of continuous glucose monitoring. Diabetes Care 2015;38:e162-e163
23. Schlüter S. Ambulatory glucose profile versus glucose logbook - Results of a survey of registered diabetes specialists in Germany. Perfusion 2015;28:123-33
24. Di Cianni G, Miccoli R, Volpe L, Lencioni C, Del Prato S. Intermediate metabolism in normal pregnancy and in pregnacy complicated by gestational diabetes. Diab Metab Res Rev 2003;19:259-70.
25. Beshyah SA, Fiad TM, Saadi HF. Management of common endocrine conditions other than diabetes mellitus during Ramadan fasting. Ibnosina J Med BS 2012;4(4):137-46
26. Ritz P, Vaurs C, Barigou M, Hanaire H. Hypoglycemia after gastric bypass: mechanisms and treatment. Diabetes Obes Metab 2016;18(3):217-23.

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