Diabetes & Metabolic Syndrome: Clinical Research & Reviews xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Diabetes & Metabolic Syndrome: Clinical Research & Reviews

journal homepage: www.elsevier.com/locate/dsx

Original Article

Targeting postprandial blood sugar over fasting blood sugar: A clinic based comparative study

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ARTICLE INFO

Article history:
Available online xxx

Keywords:
Glycosylated hemoglobin
Outpatient management
Sole marker
Glycemic control

ABSTRACT

Introduction: Recent studies indicate that modulation of post prandial blood sugar (PPBS) plays an important role in the long term glycemic control. Measurement of PPBS is more convenient for patients attending outpatient clinics than fasting blood sugar (FBS) as the former needs only two hours of fasting from the last meal.
Objective: To assess the value of PPBS monitoring in optimization of long term glycemic control among diabetic patients attending an outpatient clinic.
Methods: A total of 240 patients with type 2 diabetes (T2DM) attending an out-patient medical clinic were randomized to either PPBS or FBS monitoring. Those who selected to PPBS-group underwent blood sugar measurement 2-h after last meal on the day of their clinic visits and those in the FBS group underwent blood sugar measurement after fasting overnight (8–10 h) in the morning of their clinic visits. Treating team was asked to optimize the anti-diabetic medications based on the available PPBS or FBS results. All patients were followed up monthly for six months. Glycemic control was assessed with glycosylated hemoglobin (HbA1c) at baseline and six months later.
Results: Baseline characteristics of the two arms including age, gender, and duration of T2DM were not significantly different. Mean HbA1c (SD) of FBS and PPBS arms at baseline were 7.20 (0.45), and 7.33 (0.43) and were not significantly different (P = 0.115). During the study period, HbA1c dropped by 0.20 in FBS arm compared to 0.25 drop in PPBS arm (p = 0.59). Incidence of hypoglycemia was similar in FBS (2.42%) and PPBS arms (2.70%).
Conclusion: Monitoring of PPBS is a safe and effective alternative to FBS to optimize glycemic control in managing patients with T2DM attending outpatient clinics.

1. Introduction

Type 2 diabetes mellitus (T2DM) is a common and yet a serious medical condition associated with disability, premature death, and enormous medical costs [1]. Prospective, randomized studies have shown that optimal glycemic control retard the progression of complications, particularly microvascular complications [1,2].

Glycemic control in patients with T2DM is usually assessed by fasting blood sugar (FBS) and glycosylated haemoglobin (HbA1c). However, measurement of postprandial blood sugar (PPBS) has also been widely practiced for monitoring of blood glucose [3]. Because blood glucose concentrations vary widely during a 24-h period and from day to day in diabetes, the measurement of HbA1c is the most accepted indicator of long-term glycemic control [3,4]. However, HbA1c is not available in the state health sector hospitals in Sri Lanka at present and it can cost up to Rs. 1000 in a private laboratory. Most patients attending clinics at state health sector are not in a position to afford it. Therefore, the majority with diabetes followed up at outpatient clinics are managed with FBS. There are evidences that targeting FBS is an effective strategy in reducing short term and long term complications of diabetes [5]. However, FBS is inconvenient to some patients with diabetes attending out-patient clinics as they have to remain fasting overnight. This is especially true for those who come from long distances to the out-patient clinics, elderly patients and those who experience hypoglycemia with fasting.

On the other hand, PPBS monitoring is a more practical, less cumbersome and cost effective strategy as it needs only two hours fasting from last meal. A major interest in PPBS monitoring has also emerged in recent past, because of a plethora of new medications that specifically target PPBS [6,7]. In addition, various studies have

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http://dx.doi.org/10.1016/j.dsx.2016.06.029
1871-4021/

also suggested that raised PPBS is an independent risk factor for cardiovascular diseases [7–9]. However, it was unclear whether the PPBS alone can be used effectively in monitoring blood sugar control in outpatient clinics. Hence the aim of the present study was to assess the effectiveness of the PPBS monitoring and compare it with FBS monitoring.

2. Methods

This study was conducted in an outpatient medical clinic in a tertiary care hospital, in Sri Lanka. The study was commenced after the approval of the institutional ethics committee, Faculty of Medicine, Galle, Sri Lanka. A total of 240 patients with T2DM attending to an out-patient medical clinic were recruited by open invitation method. Informed written consent was taken from all participants. Following patients were excluded from the study; patients with oral hypoglycemic failure, on insulin therapy, type 1 diabetes mellitus, poor compliance and multiple co-morbidities including recent acute coronary syndrome/stroke (within last one year), ongoing chest pain, infections, and BMI more than 27. Data on age, sex, body mass index, duration of diabetes, type of oral hypoglycemic agents used, self-reported dietary and drug compliance, side effects of medications were collected using pre-test questionnaire at baseline and at each follow up visits during the study period.

At recruitment, all patients were randomized to either PPBS or FBS monitoring and then followed up at monthly intervals for six months. Those who selected to PPBS-group underwent blood sugar measurement 2-h after last meal on the day of their clinic visits and those in the FBS group underwent blood sugar measurement after fasting overnight (8–10 h) in the morning of their clinic visits. Treating team was requested to optimize the anti-diabetic medications based only on the available PPBS or FBS results. HbA1c was assessed at the time of recruitment and six months later to assess their glycemic control at baseline and end of the study.

Collection of blood samples was carried out by qualified medical laboratory technicians using standard protocols. All laboratory tests were quality controlled and abnormal results were repeated and confirmed. Plasma glucose measurements were carried out with an automated analyser using the glucose oxidase method at Faculty of Medicine, University of Ruhuna. Determination of HbA1c was done using standard turbidimetric immunoassay (Boehringer Mannheim, Germany).

3. Statistical analysis

To compare the mean values between the groups independent *t*-test was used and for proportions, Chi-square test was employed. P-value < 0.05 was considered statistically significant. Data analysis was done using statistical package for social science (SPSS) version 17.

4. Results

As shown in Table 1, 110 patients in FBS arm and 116 patients in PPBS arm completed the six months study period. Baseline characteristics of the patients in two arms including age, gender, and duration of T2DM, comorbidities, and the treatment types were not significantly different.

There were fluctuations of mean FBS and PPBS during the study period with downward trends observed in second, third and sixth month (Fig. 1) and both FBS and PPBS followed similar trend of fluctuations. Overall mean FBS during the study period was 129.4 mg/dL and mean PPBS was 154.8 mg/dL.

Mean HbA1c (SD) of FBS and PPBS arms at baseline were 7.20 (0.45), and 7.33 (0.43) and were not significantly different. At the end of study period, HbA1c dropped by 0.20 in FBS arm and 0.25 in PPBS arm (Table 2).

Table 1
Baseline characteristics of the patients in the study.

	FBS group N = 110	PPBS group N = 116	
	mean (SD)	mean (SD)	P
Age in years	63.3 (10.3)	62.1 (10.9)	0.54
Male/Female	24/31	22/36	
Duration years	7.73 (6.7)	7.54 (6.4)	0.23
BMI	22.1 (1.2)	22.4 (1.4)	0.34
Comorbidity			
Hypertension[a]	70	72	0.86
Dyslipidemia[a]	52	42	0.41
IHD[a]	32	24	0.12

[a] Numbers are given, FBS-fasting blood glucose, PPBS-post prandial blood glucose, BMI-body mass index, IHD- ischemic heart disease.

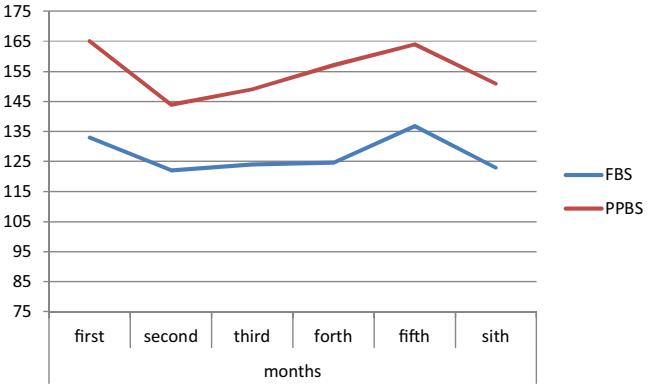

Fig. 1. mean levels of FBS and PPBS over six months.
*FBS and PPBS values are given in mg/dl, FBS-fasting blood glucose, PPBS-post prandial blood glucose.

Adverse effects and complications observed during study period is shown in Table 3. Of note the incidences of hypoglycemia were similar in the two arms (2.42% in FBS and 2.70% in PPBS). Hospital admissions were mainly due to infections (UTI in 03 patients, acute coronary event in 01 patient in FBS arm and UTI in 01 patient and acute vertigo in 01 patient in PPBS arm).

While there was a reduction in use of mono-therapy (metformin or sulphonylurea), combination therapy with metformin and sulphonylurea had risen in both arms at the end of the study period (Table 4).

5. Discussion

Managing diabetes is an art as well as a science. It is an art as available therapies have to be individualized depending on needs of patients. It is also a science as we have to manage them based on the knowledge gained from clinical research. Both clinical judgment and evidence-based knowledge are critical to our ability to effectively treat patients with diabetes.

Many observational studies have shown very significant correlations between glycemic status and both macrovascular and microvascular complications of diabetes [10]. Furthermore,

Table 2
HbA1c at baseline and 6 months later.

	HbA1c (SD) at baseline	p	HbA1c (SD) at 6 month	P
FBS	7.2 (0.45)	0.115	7.0 (0.41)	0.59
PPBS	7.33 (0.43)	–	7.08 (0.48)	–

FBS-fasting blood glucose, PPBS-post prandial blood glucose.

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Table 3
Adverse effects/complications observed during study period.

Adverse effects	FBS	n	%	PPBS	n	%
Dyspeptic symptoms**		12			8	
Hospital admission		4			2	
Hypoglycemia (minor)		1			1	
Hypoglycemia (major)*		0			0	
Cardiovascular event		1			0	

** on clinical grounds *requiring hospital admission or medical treatment, FBS-fasting blood glucose, PPBS-post prandial blood glucose.

Table 4
use of different types of oral hypoglycemic agents at the beginning and end of the study period.

Treatment	At baseline		06 months later	
	FBS	PPBS	FBS	PPBS
M only	40%	45%	36%	40%
S only	22%	24%	18%	19%
M + S	32%	28%	38%	34%
M + S + P	4%	2%	6%	5%
M + S + D	2%	0%	2%	2%

M-Metformin, S-Sulphonylurea, M + S- Metformin and Sulphonylurea, M + S + P-Metformin,Sulphonylurea and pioglitazone, M + S + D- Metformin,Sulphonylurea and Sitagliptine.

tight glycemic control in interventional studies delayed the development and progression of the microvascular complications [2,11]. Therefore, the cornerstone of diabetes management is to achieve optimal glycemic control and the evidence from many studies has revealed that HbA_{1c} is the best indicator of long-term glycemic control [12]. However, studies have shown that postprandial hyperglycemia is a significant contributor to overall glycemic control and possibly an independent contributor to diabetes outcomes [8,13,14]. Managing diabetes with PPBS may be the most appropriate test for some individuals as measurement of PPBS causes less disruption of daily activities and it obviates the need for long time fasting, which can be problematic in some elderly patients. Despite all these benefits PPBS is less utilized as a surrogate marker of glycemic control in individuals with diabetes in Sri Lanka. One reason for not using PPBS so often could be lack of strong evidence of using PPBS among patients followed up in outpatient clinics in the local setting.

A number of studies have shown acceptable correlation between HbA1c levels and FBS and PPBS level [14]. However, there is no consensus amongst professionals whether FBS or PPBS is a better predictor of glycemic control in resource poor settings particularly when HbA1c is not available. The results of this study indicate that almost similar glycemic control can be achieved by monitoring PPBS and FBS. At the end of the study period, HbA1c levels had come down in both FBS (7.0) and PPBS (7.05, P = 0.59) arms to more or less similar degree. Surprisingly, there is sparse evidence of monitoring PPBS as a sole indicator of glycemic control and comparing it with FBS.

Results: of this study is very relevant to resource poor settings as HbA1c is costly and not available in most centers and treating team has to rely on either PPBS or FBS as the surrogate marker of glycemic control.

The relative contribution of PPBS and FBS to the overall HbA1c control is different with FBS having higher contribution and PPBS having lower contribution when HbA1C is high (>8.4%) [15]. When HbA1c is close to 7% contribution of PPBS is higher than FBS. As the mean baseline HbA1c in both arms of our study was low (7.2% in FBS and 7.3% in PPBS), there was possibility that HbA1c was better controlled by targeting PPBS than FBS. However, at the end of study period there is no significant difference between HbA1c in two arms.

In this study, type of the hypoglycemic agents and their combinations used to achieve both PPBS and FBS targets were similar. This study also showed that usual combinations of oral hypoglycemic medications are sufficient to optimize PPBS. Even though newer drugs are available in targeting PPBS more than FBS [6], this study had shown similar combinations of oral hypoglycemic medications are sufficient to bring both FBS and PPBS to optimal level. Furthermore, adverse effects and other complications seen among patients in both arms were similar. Particularly, occurrence of minor and major hypoglycemic events when targeting PPBS was similar to FBS. Many previous studies too have shown that severe hypoglycemic reactions is extremely rare when targeting PPBS [2,10].

Mean PPBS achieved in this study was 154 mg/dL with lowest mean PPBS of 145 mg/dL recorded in second month of the study. Even though both of these values were higher than the recommended PPBS target of 140 mg/dL, glycemic control as indicated by HbA1c was found to be near normal (7.08). Therefore, this study indicated that desired HbA1c controlled can be achieved even with having higher PPBS target than the recommended target of 140 mg/dL.

In conclusion, results of our study show that assessment of PPBS alone offers a convenient and a reliable alternative to the FBS for patients with diabetes mellitus follow up in outpatient clinics in resource poor settings. Results of this study also indicate that targeting FBS or PPBS alone is sufficient to achieve good glycemic targets as indicated by HbA1c.

Disclosure

We would like to declare that we have no conflicts of interest in this work.

Acknowledgements

We would like to thank the participants of this study, all the staff of the University Unit of Teaching Hospital, Galle and consultants who kindly consented to use their patients. A special word of thank is extended to K. M Kumuduni de Silva and K S M Weerarathna for laboratory assistance, and Dr SP Mohotti, and Dr CM De Silva for their assistance in conducting this study.

References

[1] Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). UK Prospective Diabetes Study (UKPDS) Group. Lancet 1998;352(9131):837–53.
[2] Ohkubo Y, Kishikawa H, Araki E, Miyata T, Isami S, Motoyoshi S, et al. Intensive insulin therapy prevents the progression of diabetic microvascular complications in Japanese patients with non-insulin-dependent diabetes mellitus: a randomized prospective 6-year study. Diabetes Res Clin Pract 1995;28(2):103–17.
[3] Inzucchi SE, Bergenstal RM, Buse JB, Diamant M, Ferrannini E, Nauck M, et al. Management of hyperglycemia in type 2 diabetes, 2015: a patient-centered approach: update to a position statement of the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care 2015;38(1):140–9.
[4] Lebovitz HE, Austin MM, Blonde L, Davidson JA, Del Prato S, Gavin JR, et al. ACE/AACE consensus conference on the implementation of outpatient management of diabetes mellitus: consensus conference recommendations. Endocr Pract 2006;12(Suppl. 1):6–12.
[5] Holman RR, Turner RC. Optimizing blood glucose control in type 2 diabetes: an approach based on fasting blood glucose measurements. Diabetic Med 1988;5(6):582–8.
[6] Bastyr 3rd EJ, Stuart CA, Brodows RG, Schwartz S, Graf CJ, Zagar A, et al. Therapy focused on lowering postprandial glucose, not fasting glucose, may be superior for lowering HbA1c. IOEZ Study Group. Diabetes Care 2000;23(9):1236–41.
[7] Postprandial blood glucose. American Diabetes Association. Diabetes Care 2001;24(4):775–8.
[8] Monnier L. Is postprandial glucose a neglected cardiovascular risk factor in type 2 diabetes? Eur J Clin Invest 2000;30(Suppl. 2):3–11.

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[9] Avignon A, Radauceanu A, Monnier L. Nonfasting plasma glucose is a better marker of diabetic control than fasting plasma glucose in type 2 diabetes. Diabetes Care 1997;20(12):1822–6.
[10] Davidson J. Should postprandial glucose be measured and treated to a particular target? Yes. Diabetes Care 2003;26(6):1919–21.
[11] The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. The Diabetes Control and Complications Trial Research Group. N Engl J Med 1993;329(14):977–86.
[12] Stratton IM, Kohner EM, Aldington SJ, Turner RC, Holman RR, Manley SE, et al. UKPDS 50: risk factors for incidence and progression of retinopathy in Type II diabetes over 6 years from diagnosis. Diabetologia 2001;44(2):156–63.
[13] Soonthornpun S, Rattarasarn C, Leelawattana R, Setasuban W. Postprandial plasma glucose: a good index of glycemic control in type 2 diabetic patients having near-normal fasting glucose levels. Diabetes Res Clin Pract 1999;46(1):23–7.
[14] Buse JB. Should postprandial glucose be routinely measured and treated to a particular target? No!. Diabetes Care 2003;26(5):1615–8.
[15] Monnier L, Colette C. Contributions of fasting and postprandial glucose to hemoglobin A1c. Endocr Pract 2006;12(Suppl. 1):42–6.

Please cite this article in press as: H.M.M. Herath, et al., Targeting postprandial blood sugar over fasting blood sugar: A clinic based comparative study, Diab Met Syndr: Clin Res Rev (2016), http://dx.doi.org/10.1016/j.dsx.2016.06.029