High Carbohydrate Diet in the Treatment of Diabetes Mellitus

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Summary. Restriction of carbohydrate in the diet of diabetics is widely advocated and practised in the Western Countries, but poses a special problem in the treatment of vegetarian diabetic patients in India, since cereals like wheat and rice constitute the major bulk of their diet. Drastic changes in the diet may be needed to curtail carbohydrate intake. 25 adult-onset diabetic patients were therefore allowed to eat their customary diet, and the control of their diabetes was studied. Restrictions were made only in the total caloric intake, where needed, by curtailing fats. The average carbohydrate consumption was 342 g, constituting 67% of the average total caloric intake. Prompt and adequate clinical and biochemical control of diabetes could be achieved by a moderate dose of oral hypoglycaemic agents or insulin, and maintained during their followup period of 6 months to 8 years without any difficulty despite their high carbohydrate intake. Advantages of such a diet are enumerated.

Alimentation riche en hydrates de carbone au cours du traitement du diabète sucré

Résumé. La restriction des hydrates de carbone dans le régime des diabétiques est largement recommandée et pratiquée dans les pays occidentaux, mais pose un problème particulier dans le traitement des diabétiques végétariens en Inde, car les céréales telles que le blé et le riz constituent la majeure partie de leur régime. Des changements énergiques dans le régime peuvent être nécessaires pour diminuer la prise d'hydrates de carbone. 25 diabétiques adultes ont donc été autorisés à suivre leur régime habituel, et l'équilibre de leur diabète a été étudié. Les restrictions étaient faites seulement dans l'apport calorique total, quand cela était nécessaire, par réduction des matières grasses. La consommation moyenne d'hydrates de carbone était de 342 g, constituant 67% de l'apport

calorique total moyen. Un bon contrôle clinique et biochimique du diabète pouvait être réalisé par l'administration d'une dose modérée d'agents hypoglycémisants oraux ou d'insuline, et maintenu sans difficulté pendant la période d'observation allant de 6 mois à 8 ans, malgré l'apport élevé d'hydrates de carbone. Les avantages d'un tel régime sont énumérés.

Kohlenhydratreiche Diät in der Behandlung des Diabetes mellitus

Zusammenfassung. Die Einschränkung der Kohlenhydrate in der Diät des Diabetikers wird in den Ländern des Westens viel empfohlen und geübt; sie bietet aber bei der Behandlung von diabetischen Vegetariern in Indien spezielle Probleme, da bei ihnen Getreideprodukte wie Weizen und Reis den überwiegenden Teil der Diät ausmachen. Eine Einschränkung der Kohlenhydratzufuhr würde daher bei diesen Patienten auf eine ausgesprochen drastische Umstellung der Diät hinauslaufen. Bei 25 Diabetikern vom Erwachsenen-Typ wurde daher die Einstellung des Diabetes kontrolliert, während sie ihre gewohnte Kost beibehielten. Soweit eine Kalorieneinschränkung erforderlich war, erfolgte sie durch Verringerung der Fettzufuhr. Der durchschnittliche Kohlenhydratverbrauch belief sich dabei auf 342 g, d.h. 70% der mittleren Kalorienaufnahme/Tag. Trotz der hohen KH-Zufuhr ließ sich bei diesen Patienten ohne Schwierigkeiten mit mittleren Dosen von oralen Antidiabetika oder Insulin eine gute Diabetes-Einstellung während der Untersuchungsperiode, die sich über 1/2—8 Jahre ausdehnte, erzielen. Die Vorteile einer derartigen Diät werden aufgeführt.

Key-words: High carbohydrate diet, adult-onset diabetes, control of diabetes.

Introduction

Several published reports recommend that, on an average, carbohydrate should not constitute more than 40 to 50% of total caloric intake in the diet of diabetics [1, 3, 6, 8, 10]. Consumption of more than 200 to 250 g of carbohydrate per day is not desirable, and may make the control of diabetes difficult [1]; besides, it may increase the insulin requirement, and with it the possible frequent occurrence of hypoglycaemic reactions [1].

To restrict carbohydrate intake to 40% of total caloric intake is not difficult in non-vegetarians. Doughday [3] mentions that carbohydrate constitutes about 45 to 50% of total caloric intake in the diet of most Americans. However, vegetarian Indians consume a diet in which carbohydrate constitutes 65 to 75% of their total caloric intake, since cereals like rice, wheat and dal constitute their staple food. Both rice

and wheat are very rich in carbohydrate, and restriction of carbohydrate intake cannot be made without restricting them. Such drastic changes in the diet are unlikely to be adhered to over a long period. Having faced such a problem many times, we decided to study the control of diabetes in 25 patients on a high carbohydrate diet. Attention was mainly focussed on whether adequate biochemical control is possible despite a high carbohydrate diet, and whether the requirement for insulin or a hypoglycaemic agent goes up unduly high.

Material and Method

25 adult-onset diabetic patients attending the Diabetic Clinic of the King Edward Memorial Hospital were taken for the study. There were 15 males and 10 females. Duration of their diabetes varied from one to 7 1/2 years. Their ages varied from 37 to 73 years with a mean of 50 years, as shown in Table 2.

Each patient underwent detailed physical examination, ophthalmoscopic examination, fluoroscopic examination of the chest, urine analysis and a glucose tolerance test at the time of his first attendance, and every three months during follow-up with treatment, so as to judge the biochemical control of diabetes.

Each patient was advised to divide his total daily

Table 1. *Composition of typical vegetarian diet*

	quantity	protein in g	carbo- hydrate in g	fats in g	calories
Milk	300 ml	12.9	15.3	9.0	
Atta (Wheat flour)	200 g	24.2	138.8	3.4	
Rice	200 g	13.6	156.4	1.0	
Dal	20 g	4.6	11.6	0.3	
Vegetables (mixed)	50 g	1.2	3.6	0.1	
Butter-Milk	180 ml	1.4	0.9	1.8	
Banana	One	0.6	13.3	0.6	
Fats (for cooking)	60 g			60.0	
Total		58.5	339.9	76.2	2279

intake into three meals, namely breakfast, lunch and dinner. All of them were instructed to avoid concentrated sugars in order to avoid wide fluctuations in the blood sugar level. No changes were made in their routine menu at all. The isocaloric exchanges were freely permitted, as desired; they too involved cereals. The calculations of their dietetic intake were made by detailed interrogation by one of us. The patients were asked to weigh the raw materials of their daily rations, and the 24 h intake of fat, protein and carbohydrate and total calories was calculated as accurately as possible. Subsequently, patients were instructed to consume the same ration daily. A typical diet is shown in Table 1.

An attempt was made to keep the glucose tolerance and post-prandial blood sugar levels as near to the normal limits as possible, by using adequate doses of oral hypoglycaemic agents. No changes in their diet were made even when control was difficult. We preferred to raise the dose of hypoglycaemic agents instead, to establish adequate biochemical control. However, in order to avoid excessive weight gain, quantitative restriction was advised without any qualitative change in the diet, in some of the patients.

Table 2. *Duration of Diabetes, Age, Sex, Weight before and after Therapy, Diet and Treatment*

Serial No.	Duration of Diabetes in years	Age	Sex	Wt. before therapy in kg	Wt. at present in kg	Diet				Percentage calories from CHO sources	Treatment daily maintenance dose
						CHO	Protein	Fats	Calories		
						(in g/day)					
1.	2	60	F	54.3	50.8	253	47	41	1569	64%	Carbutamide 1 g
2.	4	43	F	66.2	64.4	386	57	49	2213	69%	Tolbutamide 1 g
3.	3	60	F	56.7	59.4	288	61	44	1792	64%	Carbutamide 1 g + Biguanide 25 mg
4.	2	45	F	51.7	52.1	395	68	45	2257	70%	Carbutamide 1 g
5.	2	46	F	62.1	59.9	327	51	59	2143	65%	Carbutamide 1.5 g + Biguanide 100 mg
6.	5	46	M	64.4	64.4	450	86	68	2756	65%	Carbutamide 0.75 g
7.	5	45	F	68.0	64.9	312	53	53	1937	64%	Carbutamide 1 g + Biguanide 75 mg
8.	3½	58	F	56.7	57.1	306	53	55	1933	63%	Tolbutamide 1 g + Biguanide 75 mg
9.	3	54	M	57.1	59.4	374	77	59	2335	64%	Tolbutamide 1 g
10.	7½	52	F	61.7	60.3	328	53	60	2064	63%	Chlorpropamide 500 mg + Biguanide 75 mg
11.	6	40	M	78.5	77.1	345	55	52	2095	67%	Tolbutamide 1 g
12.	2½	42	M	39.0	41.7	382	75	68	2440	62%	Tolbutamide 1 g
13.	1½	56	F	65.3	63.0	328	56	63	2103	62%	Carbutamide 1 g + Biguanide 50 mg
14.	3	54	M	59.4	59.4	365	59	61	2245	65%	Chlorpropamide 250 mg
15.	1	42	F	47.2	45.8	345	57	56	2112	65%	Carbutamide 1 g
16.	4	54	M	51.2	50.8	342	52	22	1785	76%	Carbutamide 1 g
17.	2	65	M	66.7	64.4	267	44	39	1600	66%	Carbutamide 1 g + Biguanide 50 mg
18.	1½	46	M	61.7	61.7	295	47	40	1618	72%	Tolbutamide 1 g
19.	2	50	M	72.1	72.6	386	75	56	2355	66%	Tolbutamide 1.5 g
20.	3	52	M	66.7	64.4	362	62	44	2097	69%	Carbutamide 1.5 g
21.	1	47	M	53.1	55.8	547	94	63	3141	69%	Carbutamide 0.75 g + Biguanide 50 mg
22.	4	39	M	59.9	58.9	342	65	48	2071	66%	Tolbutamide 1.5 g
23.	7	61	M	57.1	55.8	309	50	37	1775	69%	Carbutamide 1 g
24.	5	37	M	54.9	52.6	318	57	26	1722	76%	Carbutamide 1 g
25.	5	73	M	53.1	53.1	268	48	34	1573	74%	Chlorpropamide 25 mg

Results

As seen in Table 2, total caloric intake varied from 1570 to 3140 per day. Carbohydrate, fat and protein consumption varied from 268 to 547 g, from 22 to 68 g and from 47 to 94 g respectively. The average carbohydrate, protein and fat consumptions were 342 g, 59 g and 48 g respectively. Carbohydrates constituted 62%

of central nervous system, peripheral vascular disorders or albuminuria did not develop during that period in the 25 patients.

Follow-up

All 25 cases were followed up for a period varying from 6 months to 8 years as shown in Table 4

Table 3. Results of Glucose Tolerance Tests before and after Therapy, and Mean Glucose Tolerance during Follow-up

Serial No.	Before Treatment				After Control				Mean G.T.T. During Follow-up			
	Fasting	1h	1½h	2h	Fasting	1h	1½h	2h	Fasting	1h	1½h	2h
1.	235	340	380	380	138	215	237	220	126	217	238	238
2.	150	252	240	198	76	157	140	122	124	180	156	120
3.	140	186	220	190	102	126	114	114	90	90	102	126
4.	186	324	324	296	102	174	144	108	108	170	135	132
5.	186	288	306	276	114	198	198	142	90	186	180	102
6.	133	175	189	154	96	144	136	112	84	147	119	117
7.	161	280	273	262	105	224	182	149	102	168	164	114
8.	126	264	288	270	85	214	168	140	90	192	158	140
9.	126	180	198	168	104	176	172	138	100	170	150	140
10.	130	220	280	260	119	175	154	133	84	136	156	125
11.	250	398	365	308	115	170	120	120	95	165	140	120
12.	240	380	365	290	105	168	150	125	102	195	180	140
13.	114	222	262	222	84	132	192	126	102	150	180	156
14.	178	291	281	252	102	180	144	126	114	168	154	144
15.	128	222	258	257	90	150	168	140	84	149	147	127
16.	161	277	292	300	94	135	134	109	102	168	144	140
17.	133	231	259	259	108	198	137	116	114	188	158	130
18.	171	320	298	292	98	140	140	133	120	156	168	130
19.	180	229	292	200	126	222	162	114	120	216	168	120
20.	167	288	190	184	118	190	150	110	124	186	148	130
21.	170	252	235	210	86	168	138	114	126	170	152	118
22.	163	284	220	198	88	178	138	120	114	180	158	130
23.	90	240	252	192	72	150	144	102	120	168	148	118
24.	130	236	260	220	90	188	168	140	113	188	170	135
25.	168	290	240	240	100	168	128	90	116	200	147	130

to 76% of the total caloric intake. On an average, 67% of the total caloric intake was derived from carbohydrate.

In Table 3 are shown the results of glucose tolerance tests before and after therapy, and during follow up. In all cases adequate clinical and biochemical control of diabetes could be achieved with a moderate dose of oral hypoglycaemic agents. Oral hypoglycaemic agents used were carbutamide, tolbutamide, chlorpropamide and a biguanide derivative, either alone or in combination. The maximum dose of hypoglycaemic agent used in the series was carbutamide 1.5 g + biguanide 100 mg in 24 h in one patient, as seen in Table 2. Adequate control could be maintained throughout all the period of treatment. Hypoglycaemic reactions were not encountered, since the drug requirement was not unduly high. Two patients who developed cataract were above 60 years of age, and it is difficult to say whether it was due to diabetes. Early retinopathy was noted in 4 cases. During the follow-up period, varying from six months to seven years, there were no episodes of acidotic coma. The manifestation of complications

Table 4. Duration of follow-up of 25 patients

Duration of follow-up	Number of cases
6 months — 1 year	1
1 year — 3 years	10
3 years — 5 years	9
5 years — 7 years	3
7 years — 10 years	2

Throughout all this period we encountered no difficulty in adequately controlling their hyperglycaemia. Patients were happy since it had simplified their treatment considerably. The average glucose tolerance test during follow-up is shown in Table 3.

Discussion

It is interesting to compare the recommended diet at the Mayo Clinic [11] for adult diabetic patients with the diet of the patients in the present series, as shown in Table 5.

Table 5. Comparison of recommended diet at the Mayo Clinic for adult diabetic patients with the average diet consumed in the present series

	Carbo- hydrate (g)	Protein (g)	Fat (g)	Percent- age of calories from carbo- hydrate	Calories
Mayo Clinic diet	211	107	105	38%	2208
Present Series	342	56	48	67%	2036

Whereas carbohydrate consumption in our patients was almost one and a half times that recommended at the Mayo Clinic, fat and protein were almost half of it.

At the Mayo Clinic, carbohydrate constituted 38% of the total caloric intake, whereas on an average our patients derived 67% of their total calories from carbohydrate. A survey by BEASER [2] of members of the American Diabetes Association indicated that the vast majority of the physicians were treating their patients with restricted diet. Thus restriction of carbohydrates in the diet is widely practised.

The objections to a high carbohydrate diet in the control of diabetes are the requirement of a high dose of insulin, frequent hypoglycaemic reactions associated with the high dose of insulin, and difficult biochemical control. As seen from our results, clinical control of diabetes and control of hyperglycaemia were possible in all the cases. The majority of them could be controlled with oral hypoglycaemic agents, and the insulin requirement, in the few patients where it was used, was moderate and did not fluctuate. Although we have presented here only 25 studied cases, we have experienced no difficulty in maintaining normoglycaemia in the vast majority of our vegetarian patients at our diabetic clinic. Rice is a staple food of South Indian vegetarians, and carbohydrate may constitute for some of them as much as 80% of their total caloric intake. Even in such patients we have found no difficulty in controlling their hyperglycaemia, despite their high carbohydrate consumption. This has been the experience of several other authors [5, 9]. EARNEST et al. [5] while experimenting with isocaloric diets of various compositions, found that diets of extreme compositions can be tolerated without clinical complications, at least for a short term. They kept the patients on diets with carbohydrate as high as 71 to 73% of their total caloric intake, and they found it easier to maintain the blood sugar at the same level as before or even at lower levels. In their series, most of the patients could be controlled with a smaller dose of insulin, especially those who lost considerable weight. Only once did they note hypoglycaemic coma, since contrary to the popular belief, there was no increase in insulin requirement with high carbohydrate intake. As seen in Table 2, none of our patients lost significant weight. As a matter of fact a few gained a little weight.

It is therefore our belief that maintenance of adequate biochemical control despite such high carbohydrate intake, is not due to weight loss.

FORSYTH et al. [7] mention that endogenous hyperglycaemia should be differentiated from exogenous hyperglycaemia. Endogenous hyperglycaemia is the result of the breakdown of glycogen storage and tissue proteins, and is an expression of poor carbohydrate utilization. It is usually accompanied by ketosis. Whereas exogenous hyperglycaemia results from abundant carbohydrate intake and is not accompanied by ketosis. The undesirability of endogenous hyperglycaemia is unanimously agreed upon, but that of exogenous hyperglycaemia is questionable [7]. Besides, we see no reason in restricting carbohydrate intake when we could control even exogenous hyperglycaemia, and could keep the glucose tolerance reasonably near the normal limits.

In fact, it has been recommended that carbohydrate intake should be kept high in diabetic patients [5, 9]. Decreased glucose oxidation results in the disturbances of oxidation, synthesis, and mobilization of lipids. The aim in the treatment should be to increase glucose oxidation to a normal rate, and this can be achieved by raising carbohydrate intake. Moreover, there would be decrease in fat content of the diet, which should diminish the tendency to ketoacidosis [5].

We do not recommend a free diet in the sense used by some workers, who allow their patients to eat whatever they choose, except concentrated sugars to prevent wide fluctuations, and give them hypoglycaemic agents in a dose sufficient to control their symptoms [12, 13]. Some hyperglycaemia and glycosuria was permissible, and in fact unavoidable, with that type of treatment. On the other hand, our therapeutic aim was to maintain the normoglycaemia as effectively as possible, despite their high carbohydrate diet. The only restriction that we imposed was to keep the caloric intake at a level just sufficient for their requirements, in order to avoid excessive weight gain.

The advantages of such treatments are very distinct. Major changes in the patient's routine diet and imposing rigid restrictions are likely to cause psychological upsets. Since the treatment of diabetes lasts the life time, it may be that the patient may not persevere with the treatment for a long time.

Where carbohydrate is restricted, caloric intake can be made up only from protein and fat. This increases the cost of treatment considerably. The majority of our patients belong to the lower socio-economic group, and hence cannot afford such a treatment. Vegetarians here have very limited sources of proteins, and hence it is very difficult to raise their protein intake. The present study leads us to believe that adult-onset diabetics in our country tolerate carbohydrate very well, and there is no need to restrict the carbohydrate content of their diet, since adequate biochemical control is possible without difficulty.

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