Effect of a High-Monounsaturated Fat Diet Enriched With Avocado in NIDDM Patients

ISRAEL LERMAN-GARBER, MD
SAGRARIO ICHAZO-CERRO, PHD
JOSÉ ZAMORA-GONZÁLEZ, PHD
GUILLERMO CARDOSO-SALDAÑA, PHD
CARLOS POSADAS-ROMERO, MD

OBJECTIVE — To assess the effects of two controlled diets, one rich in oleic acid obtained from avocado and olive oil and the other rich in complex carbohydrates, on fasting and postprandial serum lipids and glycemic control in 12 women with NIDDM.

RESEARCH DESIGN AND METHODS — A randomized crossover study was designed. During a 4-week baseline period, all patients received the isocaloric diets recommended by the American Diabetes Association. After this period the patients were randomly assigned to receive the two study diets alternately during two 4-week periods. One diet was high in monounsaturated fatty acids (HMUFA) and the other was high in complex carbohydrates (high-CHO). There also was a 4-week washout period in between the two 4-week periods during which the patients followed the American Diabetes Association's isocaloric diet. Blood samples were obtained before and after each dietary period.

RESULTS — Both diets had a minor hypocholesterolemic effect with no major changes in high-density lipoprotein cholesterol. The HMUFA diet was associated with a greater decrement in plasma triglycerides (20 vs. 7% in the high-CHO diet). Glycemic control was similar with both diets.

CONCLUSIONS — Partial replacement of complex digestible carbohydrates with monounsaturated fatty acids (avocado as one of its main sources) in the diet of patients with non-insulin-dependent diabetes mellitus improves the lipid profile favorably, mantains an adequate glycemic control, and offers a good management alternative.

From the Department of Endocrinology, National Institute of Cardiology Ignacio Chávez, Mexico City, Mexico.

Address correspondence and reprint requests to Israel Lerman-Garber, MD, Department of Endocrinology, Instituto Nacional de Cardiología Ignacio Chávez, Juan Badiano #1, Tlalpan, 14080 Mexico City, Mexico.

Received for publication 5 April 1993 and accepted in revised form 14 October 1993.

NIDDM, non-insulin-dependent diabetes mellitus; HMUFA diet, high–monounsaturated fatty acids diet; high-CHO diet, high-carbohydrate diet; LDL, low-density lipoprotein; HDL, high-density lipoprotein; CV, coefficient of variation.

Dietary treatment represents the cornerstone in the management of diabetes (1). High-carbohydrate, low-fat diets are currently recommended because they consistently lower low-density lipoprotein (LDL) cholesterol (1–5). However, diabetic dyslipidemia frequently involves hypertriglyceridemia and/or hypo-α-lipoproteinemia (6). For this reason, many authors have suggested modifications to these dietary guidelines, particularly that monounsaturated fats be used as a better replacement for saturated fatty acids than carbohydrates. An excessive amount of carbohydrates in the diet can, in certain groups of patients, contribute to a more marked hypertriglyceridemia and/or postprandial hyperglycemia (7–12).

Foods containing monounsaturated fats are scarce, and most studies have been limited to the use of olive oil. Avocado has a high content of monounsaturated fatty acids (oleic acid), and large quantities of this fruit are consumed in Mexico and some other countries. The purpose of this study was to compare the effects of a high-carbohydrate (CHO) diet with a high–monounsaturated fatty acids (HMUFA) diet (a significant portion of which was derived from avocado) on glycemic control and the lipid and lipoprotein profile of patients with non-insulin-dependent diabetes mellitus (NIDDM).

RESEARCH DESIGN AND METHODS

— Sixteen female patients with NIDDM were studied at the National Institute of Cardiology Ignacio Chávez Endocrinology Department. All had a previous diagnosis of NIDDM based on the National Diabetes Data Group criteria. The patients had good metabolic control (mean fasting blood glucose levels <7.77 mM) and no major complications related to diabetes. Most of them were on oral hypoglycemic agents associated with diet, and none had previously received insulin. Some had hypertension and/or atherosclerotic heart disease and were on diuretics, ACE (angiotensin-converting

Table 1—*Mean composition of the study diets*

	ADA diet	HMUFA diet	High-CHO diet
Total fat (% of total energy)	30	40	20
Saturated	10	11	6.6
Monounsaturated	10	24	6.6
Polyunsaturated	10	5	6.6
P:S ratio	1	0.45	1
Carbohydrates (% of total energy)	55	40	60
Proteins (% of total energy)	15	20	20
Cholesterol (mg/day)	<300	<300	<300

Both diets were isocaloric, the fiber content was ~30 g in the HMUFA diet and 42 g in the high-CHO diet. ADA, American Diabetes Association; P:S, polyunsaturated:saturated.

enzyme) inhibitors, or calcium channel blockers, which were continued with no changes during the study. None had had a recent occurrence of myocardial infarction, unstable angina, or congestive heart failure. Also, none of the patients had thyroid, renal, or hepatic disease or had received a hypolipidemic agent in the 3 months before the study. Of the original 16 patients, only 12 are included in this report. Their mean ± SD age was 56 ± 8 years, and the body weight and body mass indexes averaged 66 ± 10 kg and 28 ± 4 kg/m^2, respectively.

A randomized crossover study was designed. During a 4-week baseline period, the patients received the isocaloric diets recommended by the American Diabetes Association. After this period, the patients were randomly assigned to alternately receive both study diets—the HMUFA and high-CHO diets—during two 4-week periods with a 4-week period in between during which the patients were kept on the American Diabetes Association's isocaloric diet. Four patients were excluded because they did not comply with the dietary guidelines.

Diets

The nutrient composition of the diets is shown in Table 1. Both diets consist of solid foods, and patients were allowed some choice of food items. One avocado (Hass variety) and four teaspoons of olive oil were the main sources of fat in the HMUFA diet.

The patients were instructed to follow the diet and received menus every day (Table 2). On the 14th day and at the end of each study period, the patients were seen by the nutritionist and had a 24-h diet recall. Four patients had <80% adherence to the diet (one with >5% change in her body weight) and were excluded from the study.

At the beginning and end of each period, a mixed meal consumed in 20 min was given as a provocative test (550 kcal with the distribution pattern of each of the study diets), and the postprandial increments in insulin, glucose, and triglycerides were measured.

Biochemical analysis

On the first and last day of each period, 12- to 14-h fasting blood samples were obtained and analyzed for total cholesterol, triglycerides, LDL and high-density lipoprotein (HDL) cholesterol, glucose, insulin, and fructosamine. After the provocative mixed-meal test, glucose, insulin, and triglycerides also were measured at the first, second, and sixth hour.

Total cholesterol and triglyceride levels were determined by enzymatic methods (13,14). HDLs, including HDL_3 levels, were determined after double precipitation using $MgCl_2$ and dextran-sulfate (15). LDL-cholesterol concentration was estimated using the Friedewald equation. Laboratory methods were standardized through the National Heart, Lung, and Blood Institute–Center for Disease Control lipoprotein standardization program. Intra-assay coefficients of variation (CVs) for total cholesterol, triglycerides, and HDL cholesterol were 1.1, 0.62, and 1.14%, respectively; the interassay CVs were 3.06, 2.6, and 3.9%, respectively. Blood glucose was determined by a glucose oxidase method with commercially available kits (Test-Combination glucose GOD-PAP, Boehringer-Mannheim, Mannheim, Germany).

Fructosamine was assayed with a method that measures the reduction of nitro blue tetrazolium by serum (test-combination fructosamine, Boehringer-Mannheim) with an ABBOTT VP II analyzer. Plasma insulin was measured by enzyme-linked immunosorbent assay with commercially available kits (Enzymun-Test Insulin, Boehringer-Mannheim).

Statistical analysis

To compare the baseline periods and the two study periods, Wilcoxon's signed-rank test was used. Data are expressed as means ± SD. Differences in the postprandial metabolic variables were analyzed with their percentage changes (% Δ). Analysis was performed, when required, on the logarithms of the triglycerides to improve their skewed distribution. These variables were then converted into their natural units for presentation in the tables.

RESULTS

— The effect of the two different diets on the lipid profiles and diabetic metabolic control is shown in Table 3 and Fig. 1. Both diets had a similar and minor hypocholesterolemic effect, with no major changes in HDL cholesterol. The HMUFA diet was associated with a greater decrement in plasma triglycerides (20 vs. 7% in the high-CHO diet, NS). Figure 2 shows the individual triglycerides values before and after the two dietary periods. As can be seen, the major hypotriglyceridemic effect was obtained in patients with basal higher triglyceride values when they received the HMUFA diet. The high-CHO diet also was associ-

Table 2—*Example of a menu*

HMUFA diet*‡		High-CHO diet†‡	
Breakfast		Breakfast	
Coffee with nonfat milk	240 ml	Coffee with nonfat milk	240 ml
Enfrijolada		Entomatadas	
1 corn tortilla		3 corn tortillas	
1/2 cup beans		tomato sauce	
1/3 piece avocado		onion, lettuce	
Guavas	2 pieces	Papaya	3/4 cup
Lunch		Lunch	
Rice with vegetables	1/2 cup	Potato soup	1 1/2 cups
Roast meat	120 g	Spanish rice	1/2 cup
Beans in a bowl	1 cup	Chili with chicken and nopales	100 g
Corn tortilla	1 piece	Corn tortillas	3 pieces
Guacamole			
1/3 piece avocado			
onion, tomato			
Tangerine	1 piece	Apple	1 piece
Lemonade		Lemonade	
Dinner		Dinner	
Taco (with cooked vegetables)		Beans in a bowl	1 cup
corn tortilla	1 piece	Bread	2 slices
1/3 piece avocado			
Apple	1 piece	Orange	1 piece
Tea		Tea	

Operational definitions: tortilla: baked, flat, round, thin cakes of unleavened cornmeal (masa) or flour—the bread of México; enfrijolada: corn tortilla folded or rolled, covered with a bean sauce and garnished with onion and lettuce; entomatada: corn tortilla folded or rolled, covered with sauce of chili with tomato, and garnished with onion and lettuce; guacamole: avocado dip made with chopped chili, tomato, onion, and other seasonings; taco: corn tortilla folded in half to hold seasoned beef, beans, or vegetables; nopales (cactus): the leaves or pods of the prickly pear cactus are used; they taste like crisp green beans and are sliced in strips and cooked with onions and spices. *Four teaspoons of olive oil used for cooking. †Three teaspoons of safflower oil used for cooking. ‡Drinks could be sweetened with artificial edulcorants.

ated with minor decrements in the level of triglycerides.

The provocative mixed-meal test at the end of each experimental diet showed that the differences between the HMUFA and the high-CHO diets mainly related to the fasting glucose, insulin, and/or triglyceride levels; all three parameters diminished after each experimental diet. The percentage changes (% Δ) were otherwise similar. Although the differences were not statistically significant, the trend was toward higher postprandial glucose values after a high-CHO meal test, likely related to the fact that more carbohydrates were eaten during this meal test.

CONCLUSIONS— The study was designed to assess whether replacing carbohydrates with monounsaturated fats, most of them derived from avocado and olive oil, would induce beneficial changes in the lipoprotein patterns in patients with NIDDM.

The Mexican diet in the lower income classes is high in carbohydrates (± 60%); the amount of fat is relatively low (± 20%), but most of it is saturated and accompanied by a high amount of cholesterol. This meal pattern plus the genetic admixture and high prevalence of obesity probably explain the high prevalence of NIDDM and lipid disorders in the Mexican populations, particularly hyper-

Table 3—*Effects of the two study diets on plasma lipids, lipoproteins, and glycemic control*

	HMUFA diet			High-CHO diet		
	Before	After	*P* value	Before	After	*P* value
Glycemia (mM)	6.49 ± 1.11	5.43 ± 1.11	<0.001	7.16 ± 2.6	6.16 ± 1.38	<0.05
Fructosamine (mM)	271 ± 79	270 ± 47	NS	284 ± 67	272 ± 50	NS
Weight (kg)	65 ± 10	64 ± 10	NS	65 ± 10	65 ± 10	NS
Total cholesterol (mM)	5.22 ± 0.93	4.83 ± 0.88	<0.05	5.30 ± 0.80	5.07 ± 1.11	<0.05
LDL cholesterol (mM)	3.5 ± 0.75	3.38 ± 0.72	NS	3.69 ± 0.70	3.48 ± 0.88	NS
HDL cholesterol (mM)	0.98 ± 0.23	0.98 ± 0.26	NS	0.96 ± 0.20	0.98 ± 0.26	NS
Triglycerides (mM)	1.75 ± 0.96	1.25 ± 0.41	<0.05	1.78 ± 0.75	1.61 ± 0.68	NS

P values obtained by Wilcoxon's signed-rank test. When the different variables in the HMUFA vs. the high-CHO diets were compared, nonsignificant differences were observed between baseline values. After both dietary periods, significant differences ($P < 0.05$) were shown only with plasma triglycerides.

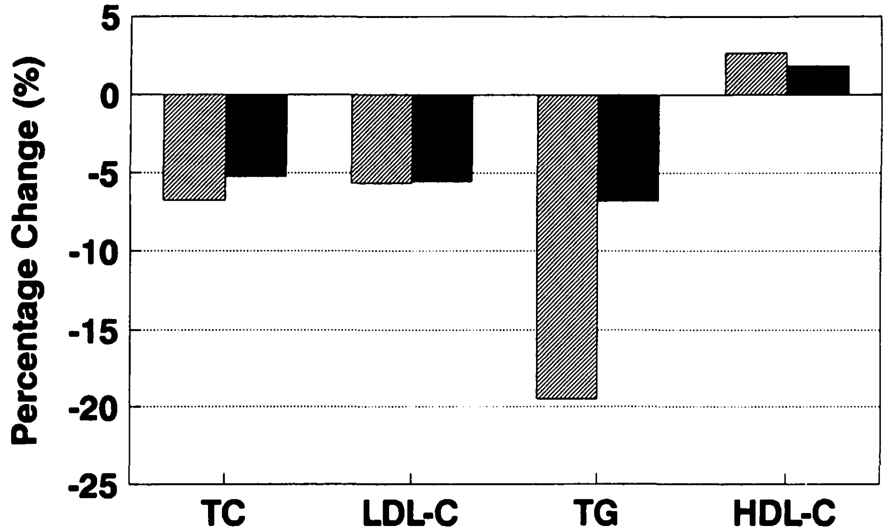

Figure 1—*The percentage of change in blood lipids after the HMUFA (▨) and high-CHO (■) diets in 12 NIDDM patients. (TC), Total cholesterol; (LDL-C), LDL cholesterol; (TG), triglycerides; (HDL-C), HDL cholesterol.*

their triglyceride levels with the HMUFA diet was particularly important. To reinforce the fact that triglyceride levels, and not order effect, were relevant to the results obtained, we present the mean triglyceride values before and after each dietary period for both groups of patients (A1, A2 and B1, B2; Fig. 3). Both diets had a hypotriglyceridemic effect, but it was only shown in the patients who had higher basal triglyceride values (group A1, A2). The group (B1, B2) with lower baseline triglyceride values had basically no changes with both diets. The study was performed in a randomized fashion, so the fact that one group of patients had higher basal triglycerides cannot be explained. Both groups of patients were similar in age, type of treatment, metabolic control, and duration of diabetes. These data do not suggest an order effect. The absence of a greater response with the HMUFA diet in the second period is likely related to the lower baseline triglyceride values. In summary, people did not do better if one diet was started first or second. The hypotriglyceridemic effect was more related to the baseline triglyceride values and reached statistical significance only for the HMUFA diet.

triglyceridemia and hypo-α-lipoproteinemia.

Avocado is among the fruits commonly used in the Mexican diet. Because it is rich in fat, avocado has not been recommended for individuals with dyslipidemias. For every 100 g of edible portion of avocado (Hass, a subtype of avocado), 144 kcal are distributed with 7.6 g of carbohydrates, 1.6 g of protein, and 11.9 g of total fat. Of this, 15.2% are saturated, 72.6% are monounsaturated (mostly oleic acid), and 12.2% are polyunsaturated with a polyunsaturated:saturated fat ratio of 0.8 (16,17). During the last few years, however, some brief reports have suggested that avocado consumption probably has no detrimental effect on the lipid profile.

In this study, both diets were well tolerated with no adverse effects, and excellent compliance was attained, probably because patients were highly motivated and had day-by-day menu selection. This is confirmed by the expected dietary reduction in total cholesterol of 5–6%, in agreement with the Keys equation, as formulated by Anderson et al. (18a).

Overall, the HMUFA diet, supplemented with avocado, showed results similar to those obtained in other studies with greater amounts of olive oil. The reduction in serum triglycerides was significant, however, the decrements in total cholesterol were only minor, and no change was observed in HDL cholesterol (7–12,18). The observation that individuals with the higher basal triglyceride values obtained significant decrements on

Potentially undesirable effects of high-CHO diets, such as reductions in

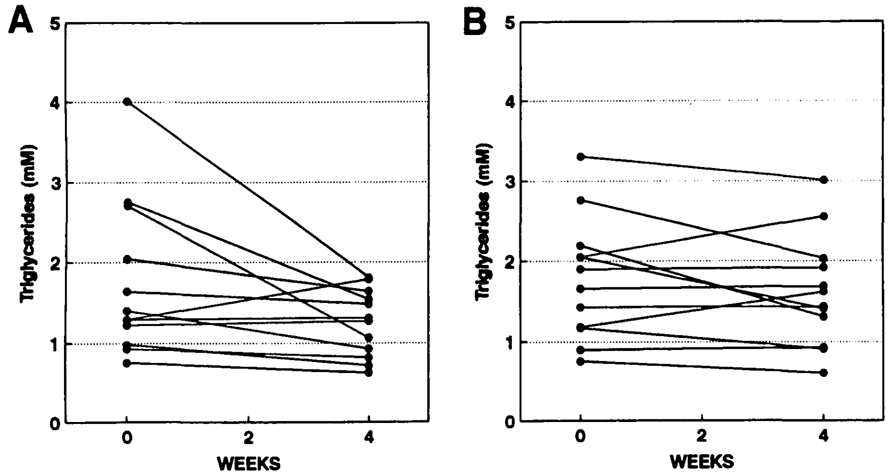

Figure 2—*Individual changes in plasma triglyceride values after the HMUFA (A) and high-CHO (B) diets.*

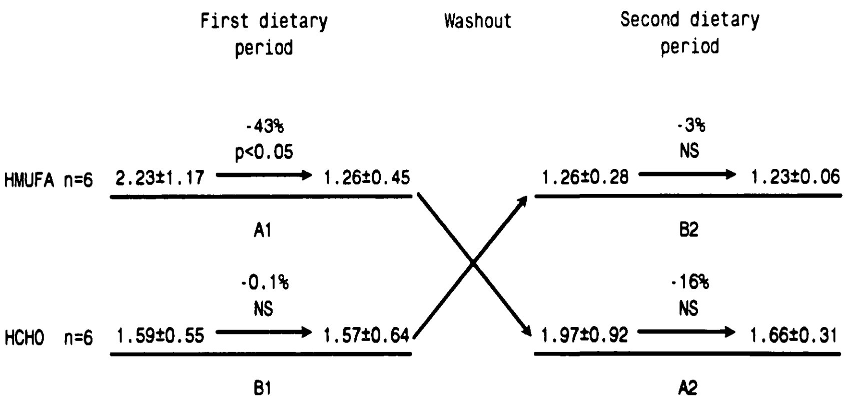

Figure 3—*Mean triglyceride values before and after each dietary period for both groups of patients* (A1, A2 *and* B1, B2).

HDL cholesterol, hyperglycemia, and/or hypertriglyceridemia (7,8,19,20), were not seen in this study. A plausible explanation is that a deleterious hyperglycemic and hypertriglyceridemic effect of these types of diets is generally found in individuals with poor metabolic control. This was not the case in this study. We could not find significant differences in the postprandial increments of triglycerides, glucose, and/or insulin levels with either diet. No differences were found in the blood glucose control between both types of diets.

In conclusion, partial replacement of complex digestible carbohydrates with monounsaturated fatty acids (avocado as one of its main sources) in the diet of patients with NIDDM favorably improves both lipid profiles, mantains an adequate glycemic control, and should be a good management alternative. Further studies are required regarding the long-term effects of the avocado.

References

1. American Diabetes Association: Nutritional recommendations and principles for individuals with diabetes mellitus. *Diabetes Care* 10:126–32, 1987
2. Anderson JW: Effect of carbohydrate restriction and high carbohydrate diets on men with chemical diabetes. *Am J Clin Nutr* 30:402–408, 1977
3. Kiehm TG, Anderson JW, Ward K: Beneficial effects of a high-carbohydrate, high-fiber diet on hyperglycemic diabetic men. *Am J Clin Nutr* 29:895–99, 1976
4. Abbot WGH, Boyce VL, Grundy SM, Howard BV: Effects of replacing saturated fat with complex carbohydrates in diets or subjects with NIDDM. *Diabetes Care* 12: 102–107, 1989
5. Howard B, Abbot WG, Swinburn BA: Evaluation of metabolic effects of substitution of complex carbohydrates for saturated fat in individuals with obesity and NIDDM. *Diabetes Care* 14:786–95, 1991
6. Gang A, Grundy SM: Management of dyslipidemia in NIDDM. *Diabetes Care* 13: 153–59, 1990
7. Bierman EL, Hamlin JT III: The hyperlipemic effect of a low-fat, high-carbohydrate diet in diabetic subjects. *Diabetes* 10:432–37, 1961
8. Coulston A, Hollenbeck CB, Swislocki ALM, Chen Y-DI, Reaven GM: Deleterious metabolic effects of high-carbohydrate, sucrose-containing diets in patients with non-insulin-dependent diabetes mellitus. *Am J Med* 82:213–20, 1987
9. Ginsberg H, Olefsky JM, Kimmerling G, Crapo P, Reaven GM: Induction of hypertriglyceridemia by a low-fat diet. *J Clin Endocrinol Metab* 42:729–35, 1976
10. Grundy SM: Comparison of effects of monounsaturated fatty acids and carbohydrates for lowering plasma cholesterol. *N Engl J Med* 314:745–48, 1986
11. Mensink RP, Katan MB: Effects of monounsaturated fatty acids versus complex carbohydrates on high-density lipoproteins in healthy men and women. *Lancet* 1:122–25, 1987
12. Gang A, Bonanome A, Grundy SM, Zhang Z, Unger RH: Comparison of a high-carbohydrate diet with a high-monounsaturated fat diet in patients with non-insulin-dependent diabetes mellitus. *N Engl J Med* 319:829–34, 1988
13. Siedel J, Hagele E, Ziengenhorn J, Wahlefield AW: Reagent for enzymatic determination of serum total cholesterol with improved lipolytic efficiency. *Clin Chem* 29:1075–80, 1983
14. Nagele U, Nagele EO, Sauer G, Wiedermann E, Lehmann P, Wahlefeld A, Gruber W: Reagent for enzymatic determination of serum total triglycerides with improved lipolytic efficiency. *J Clin Chem Biochem* 22:166–74, 1984
15. Warnick GR, Benderson J, Albers JJ: Dextran-sulfate-Mg^{+2} precipitation procedure for quantitation of high-density lipoprotein cholesterol. *Clin Chem* 28: 1379–88, 1982
16. Bourges H, Chávez A: *Tablas de Valores Nutritivos de Alimentos Mexicanos*. División de Nutrición, Instituto Nacional de la Nutrición, México, 1983
17. Shils ME, Young VR: *Modern Nutrition in Health and Disease*. 7th ed. Philadelphia, Lea & Febiger, 1988
18. Mattson F: A changing role for dietary monounsaturated fatty acids. *J Am Diet Assoc* 89:387–91, 1989

18a. Anderson JT, Jacobs DR, Foster N: Scanning systems for evaluating dietary patterns effect on serum cholesterol. *Prev Med* 8:525–37, 1979

19. Grundy SM: Dietary therapy in diabetes mellitus: is there a single best diet. *Diabetes Care* 14:796–801, 1991
20. Hollenbeck CB, Coulston AM: Effects of dietary carbohydrate and fat intake on glucose and lipoprotein metabolism in individuals with diabetes mellitus. *Diabetes Care* 14:774–85, 1991