

# Hypercholesterolaemia and Atherosclerosis Induced in Vervet Monkeys by Cholesterol-free, Semisynthetic Diets

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## SUMMARY

Vervet monkeys (*Cercopithecus aethiops pygerythrus*) were fed diets containing 40% carbohydrate, 25% casein and 14% hydrogenated coconut oil for 6 months. Three carbohydrates were fed: glucose, fructose and sucrose. All three diets were cholesterolaemic, the most severe cholesterolaemias being observed in the fructose and sucrose groups. All diets led to aortic sudanophilia. The fructose diet resulted in the most severe atherosclerosis and sudanophilia. This study demonstrates the feasibility of using semisynthetic, cholesterol-free diets for the induction of hyperlipaemia and atherosclerosis in monkeys.

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It has been demonstrated<sup>1,2</sup> that a cholesterol-free, semipurified diet containing saturated fat is atherogenic for rabbits. We have shown further<sup>3</sup> that the type of carbohydrate used in this diet may affect the severity of atherosclerosis induced in rabbits. Recently<sup>4</sup> we reported that a semisynthetic cholesterol-free diet could cause sudanophilia in baboons. This communication presents a preliminary report on the effects of this type of diet on atherosclerosis in the vervet monkey (*Cercopithecus aethiops pygerythrus*).

## MATERIAL AND METHODS

Twenty-four vervet monkeys (12 male, 12 female) were divided into 4 groups of approximately equal weight ( $4.2 \pm 0.2$  kg). There were 3 males and 3 females in each group. One group was fed a control diet of monkey chow, fruit and vegetables. The other 3 groups were placed on a basic diet of the following composition: 40% carbohydrate, 25% casein, 14% hydrogenated coconut oil, 15% cellulose, 5% salt mix (USP XIV) and 1% vitamin mix. The carbohydrate fed to each group was either glucose, fructose or sucrose. The monkeys were maintained on the various diets for 6 months, during which period they were subjected to periodic bleedings. The blood serum was analysed for total cholesterol<sup>5</sup> and other lipids. After 6 months the animals were killed while under Sernylan (1-[1-phenylcyclohexyl] piperidine HCl) anaesthesia. The livers and bile were taken for analysis.

TABLE I. EFFECTS OF A HIGH CARBOHYDRATE (40%), HIGH SATURATED FAT (14%) DIET FED TO VERVET MONKEYS FOR 6 MONTHS

Group	Av. weight (kg)		Av. serum cholesterol (mg/100 ml)		Atherosclerosis	
	Start	6 mo.	Start	6 mo.	Visual	Stained
Glucose	4,1	4,7	101 ± 6	141 ± 5*	0,5	5 ± 2*
Fructose	4,4	5,0	103 ± 8	205 ± 14	1,2	20 ± 12
Sucrose	4,2	4,9	105 ± 8	194 ± 19	0,6	3 ± 0,9
Control	4,1	4,5	101 ± 12	117 ± 12	0,2	5 ± 3

\* Standard error of the mean.

The aortas were excised, fixed in formalin and stained with Sudan IV<sup>6</sup> in order to make areas of lipid infiltration more readily visible. They were also graded visually for raised lesions using a 0-4 scale.<sup>5</sup>

## RESULTS AND DISCUSSION

The autopsy data are presented in Table I. It is evident that all four groups showed a similar weight gain (0,4-0,7 kg).

The effect of the semisynthetic diets on serum cholesterol was striking. The fructose- and sucrose-containing diets were particularly cholesterolaemic, raising the starting cholesterol levels by 90% and 76%, respectively. The glucose diet caused a 31% increase in serum cholesterol levels and the increase in cholesterol level of the control group was only 9%. Cholesterol levels in the fructose and sucrose groups were significantly higher than those in the glucose or control groups (fructose v. glucose,  $P < 0,01$ ; v. control,  $P < 0,01$ ; sucrose v. glucose,  $P < 0,05$ ; v. control,  $P < 0,01$ ).

The average starting cholesterol level of all 24 monkeys was 103 mg/100 ml. The cholesterol levels in the 3 test groups were all significantly elevated when compared with starting levels of the individual groups (glucose and fructose,  $P < 0,001$ ; sucrose,  $P < 0,01$ ). When baboons were fed similar diets for 12 months, the increase in cholesterol levels in groups fed glucose, fructose, sucrose or control diets were 26%, 19%, 22% and 1% respectively.<sup>4</sup> Visual

atheroma was most prevalent in the group fed fructose. A few of the monkeys in the glucose and sucrose groups exhibited atheroma and one of the control monkey aortas contained an atheromatous plaque. These findings are corroborated by the staining procedure.

This study shows that cholesterol-free semisynthetic diets, containing high levels of carbohydrate and saturated fat, cause significant cholesterolaemia in monkeys. A slight level of atherosclerosis was observed in the monkeys fed glucose or sucrose, but the fructose diet was frankly atherogenic.

A full report will be submitted for publication after analyses of serum, liver, aorta and bile have been completed.

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