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TECHNICAL REPORT

70-9-FL

THE EFFECT OF DIETARY FAT LEVEL ON
POSTPRANDIAL GASTROINTESTINAL BLOOD
FLOW PATTERNS

by

J. L. Mauderly

and

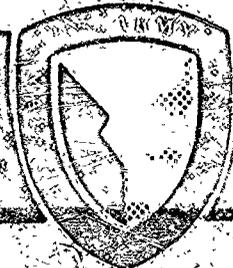
J. A. Lawrence

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FOREWORD

One method of increasing the caloric density of field rations and reducing the logistical burden of the individual is to raise the fat content. Since splanchnic blood flow increases after eating a meal and fatty foods remain in the stomach and intestines longer than low-fat foods, the question was raised about the effects of a possible prolonged high splanchnic flowrate on flow to the working muscles. This study was designed to detect possible detrimental effects of a high-fat diet on peripheral circulation and ultimately, on the performance of the individual.

In conducting the research described in this report, the investigators adhered to the "Guide for Laboratory Animal Facilities and Care" as promulgated by the Committee on the Guide for Laboratory Animal Resources, National Academy of Sciences-National Research Council.

This work was conducted under project 1JO-61102-A71C, Food Research.

ABSTRACT

To establish the effects of dietary fat on splanchnic and peripheral blood flow patterns, electromagnetic blood flow probes were chronically implanted on the coeliac and cranial mesenteric arteries and the abdominal aorta of four male beagle dogs. The dogs were fed meals of three sizes containing three concentrations of fat. Blood flowrate in the three vessels was monitored, both at rest and running on a treadmill at moderate exercise. The combined flow of the coeliac and mesenteric arteries increased to a peak flow after eating. The velocity and time of peak flow were not affected by meal size or fat content, although the time of peak flow was slightly delayed by exercise. The average splanchnic flow was unchanged by meal size, fat content, or exercise. Average abdominal aortic flow was unchanged by meal size or fat content, and was consistently increased by exercise regardless of diet regime.

INTRODUCTION

The military is continually interested in increasing the caloric density of field rations, thereby reducing the logistical burden of the individual. This can be accomplished by reducing the carbohydrate and protein fractions of the diet while increasing the percentage of fats or other energy-dense compounds.

There are, however, problems associated with high-fat diets which have raised questions as to their feasibility for combat use. Fatty foods are released more slowly from the stomach than low-fat foods due to the action of enterogastrone and the enterogastric reflex on gastric secretion and motility (1, 2). It is generally agreed that splanchnic blood circulation is increased by 30% or more after the ingestion of a meal (3, 4). Some workers report that the increase is a result of the diversion of flow from other organs to the splanchnic bed (5), while others believe it to be a result of an increased cardiac output with all organs receiving a proportionate share of flow (4, 6). If splanchnic flow rises at the expense of flow to the major working muscle masses, a prolonged increase during the post-prandial state may impair the performance of an individual when under stress, as in combat.

The purpose of this study is to determine to what extent dietary fat level affects postprandial blood flow at rest and during exercise, and at varying volumes of fat consumed per meal.

METHODS

Three semi-purified diets containing 2, 30, and 70% fat were prepared (Table 1). The only variables were fats (lard and corn oil) and carbohydrates (sucrose, dextrose, and dextrin). Four male beagle dogs weighing between 11 and 14 Kg. were trained to consume 50, 100, and 200 gram meals of the prepared diets within 5 minutes. The dogs were also trained to run on a treadmill and were kept on the treadmill during all the trials.

After sufficient training, slot-key electro-magnetic blood flow probes (Q series, Statham Medical Instruments, Los Angeles, Calif.) were implanted on the coeliac and cranial mesenteric arteries at their aortic origin and a hinge-type probe (K series, Statham) was implanted on the abdominal aorta immediately caudal to the left renal artery. The caudal mesenteric artery has no direct digestive function and was considered negligible for this study. The phase, balance, and meter polarity of the precalibrated probes were determined in vitro prior to implantation according to the procedure outlined in the Statham manual (7). A left paracostal incision 2 cm. behind the last rib was utilized for the implantation. Probes of this type have a separate ground wire, the end of which was

sutured to the abdominal wall about 2 cm. from the probe heads. The probe readings were then zeroed on the sine-wave flowmeter (Multiflow Model M-4000 Modular Electro-magnetic Flowmeter, Statham) by temporary occlusion of the vessels at the time of implantation. The wires were then brought out of the abdomen at the most dorsal aspect of the incision and extended subcutaneously to a point on the dorsal midline 2 cm. behind the caudal borders of the scapulae. At that point, the wires and connector plugs were exteriorized through the lumen of a teflon-coated hub and washer apparatus (Cardiovascular Instrument Corp., Wakefield, Mass.) which was sutured into the skin incision to minimize continued irritation of the site.

After approximately a 10-day recovery period, the subjects were placed on the schedule found in table 2. Blood flow velocity was recorded on a polygraph (Model 7, Grass Medical Instrument Co., Quincy, Mass.) calibrated to the flowmeter with a M-4000 Calibrator (Statham). The polygraph baseline and sensitivity were checked daily and only one trial was conducted per day. Before the feeding trial began, the flow was recorded for 15 minutes. The dogs were then fed and flow was recorded continuously during feeding and 1 hour afterward. Five-minute recordings were made at 15-minute intervals during the next 2 hours, and at 30-minute intervals during the following 3 hours, for a total of 2 hours and 10 minutes actual recorded flow over the 6-hour period.

The dogs were kept on the treadmill at a room temperature of 25°C. for both running and resting regimes. When running, the treadmill was set level at a speed of three mph., and during each 6-hour period the dogs ran the equivalent of 10.5 miles. Water was available ad libitum on both running and resting days.

Controls were run on the same 6-hour schedule with the exception that no food was given until after all recordings were made for the day. Both running and resting controls were taken before, after, and in the middle of the series in order to establish a control flow value for the non-digestive state. From these controls, changes in flow velocity due to treatment effect were calculated. The combined flow of the coeliac and cranial mesenteric arteries represent the splanchnic circulation and the flow in the abdominal aorta at the point monitored gives an indication of the flow available to major working muscle masses.

RESULTS

The outstanding feature of the data was the variation in flow velocity, both among the dogs and within each dog. Flow in the vessels studied varied continually throughout each 6-hour trial, seldom maintaining a constant rate for more than a few minutes. It was observed that aortic flow would increase or decrease almost instantaneously from environmental stimuli such as sights and sounds which attracted attention and all effort was made to minimize these stimuli.

Average values for each of the three vessels during each regimen were calculated and compared to the average fasting, or control values. Analysis of variance and subsequent multiple linear regression tests applied to the data indicated no significant changes in flow due to either fat concentration or amount fed per meal. Postprandial splanchnic flow increased during each feeding trial to a peak velocity occurring from a minimum of one-half hour to a maximum of three hours post-ingestion. Neither the time nor velocity of peak splanchnic flow could be attributed to either the fat content or the size of the meal involved.

Treadmill running did influence flow values obtained regardless of size or composition of the meal. Aortic flow in the fasting, or control state was increased during treadmill exercise by an average of 112.3% or 389 cc/min. over the 341 cc/min. average at rest. A similar relative increase in aortic flow occurred during each of the running trials regardless of meal size or composition. The combined coeliac and cranial mesenteric flow was reduced during the running, non-digestive state by an average of 13.5% or 37 cc/min. from the 274 cc/min. resting average. There was no significant decrease in splanchnic flow during the feeding trials due to exercise. There was no change in peak postprandial splanchnic velocity due to exercise, although the time of peak velocity was delayed slightly. Peak flow occurred at an average of 1.24 hours after feeding during resting trials and a 1.53 hours average after feeding during treadmill running, an average delay of 0.29 hours or 17 minutes.

CONCLUSIONS

Results indicate that the combined postprandial flow of the coeliac and cranial mesenteric arteries reaches a peak one and one-quarter to one and one-half hours after feeding, and the time of that peak flow is not affected significantly by the fat content or size of the meal eaten. Fasting splanchnic flow during exercise increased 59% to reach the same postprandial peak velocity attained by a 36.5% increase from fasting splanchnic flow at rest. This would seem to indicate that there is a certain splanchnic flowrate required for the processes of digestion, absorption, and motility, and that flowrate is not significantly altered by either moderate exercise or by changes in the fat content or size of the meal eaten.

Since postprandial aortic flow was unchanged from fasting aortic flow both at rest and running, the increased demand for splanchnic circulation in the postprandial state is met by some compensation other than a reduction in abdominal aortic flowrate.

TABLE I

Percentage composition of diets

<u>Ingredients</u>	<u>2% Fat</u>	<u>30% Fat</u>	<u>70% Fat</u>
Casein	22.0	22.0	22.0
Glucose	22.2	12.9	--
Sucrose	22.2	12.9	--
Dextrin	22.2	12.8	--
Lard	--	22.5	51.45
Corn Oil	2.0	7.5	17.15
Salt Mix	4.0	4.0	4.0
Vitamin Mix	1.0	1.0	1.0
Choline	0.4	0.4	0.4
Cellulose	4.0	4.0	4.0
Flavoring*	5 ml/1000 grams mixed in all diets before feeding		

* "Kitchen Bouquet", Grocery Store Products Co., West Chester, Pa.

TABLE II

Daily schedule

	<u>1st Wk.</u>	<u>2nd Wk.</u>	<u>3rd Wk.</u>	<u>4th Wk.</u>
Mon.	T control	T-50-30	T control	T-200-30
Tues.	R control	R-200-30	R-100-2	R-100-70
Wed.	T-100-2	T-100-70	T-50-2	T-50-70
Thurs.	R-50-2	R-50-70	R-200-2	R-200-70
Fri.	T-200-2	T-200-70	T-100-30	T control
Sat.	R-100-30	R control	R-50-30	R control

LEGEND: R = resting
T = running on treadmill

Amount fed in grams = 50, 100, and 200

Percentage of fat in diet = 2, 30, and 70

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Blood flow	7					
Military feeding	10					

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