Absorption of Medium Chain Triglycerides in Tropical Sprue. (29530)

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The daily consumption of fats by an average human adult is of the order of 100 g which amounts to some 40% of his total caloric requirement. Among the lipids present in the average human diet, triglycerides containing saturated and unsaturated fatty acids of 16 and 18 carbon atoms predominate. Normally those triglycerides containing fatty acids with more than 12 carbon atoms are absorbed mainly via the intestinal lacteals while those containing fatty acids with less than 12 carbon atoms are absorbed into the portal circulation(1). The fat recovered from the lymph is in the form of chylomicrons. These consist chiefly of triglycerides bound to small amounts of phospholipids, cholesterol and plasma proteins(2). The triglycerides in these chylomicrons are mainly of the same type as those found in the dietary fat, as this consists primarily of fatty acids of more than 12 carbon atoms(3).

Recently Linscheer(4) reported absorption of octanoic acid from the colon in man, and Hashim *et al*(5) reported that hydrolysis of the medium chain triglycerides occurs in the intestine before absorption of the fatty acids into the portal vein. These acids are transported in the portal vein as free fatty acids to the liver where they appear to be rapidly metabolized.

Medium chain triglycerides have been utilized in the treatment of chyluria, chylothorax and pancreatogenous steatorrhea, but not in tropical sprue. The object of the present investigation was to test the capacity of the patient with tropical sprue to absorb medium chain triglycerides, since it is known that tropical sprue patients show a diminution in their capacity to absorb naturally occurring triglycerides of animal origin in which 18 carbon fatty acids predominate.

Materials and methods. A synthetic preparation (MCT) containing saturated fatty acids with chain lengths ranging from 6 to 12 carbons has been utilized in this investigation. The product is made from the fractionation of coconut oil and represents essentially a mixture of saturated triglycerides. This saturated but liquid fat has a melting point below 0°C, and an iodine number of less than 1. In contrast with long chain saturated triglycerides, this preparation has greater miscibility with water and a lower melting point, properties usually associated with a high degree of unsaturation. MCT represents about 15% of the original coconut oil. It is a clear, thin, odorless liquid containing 1.9% caproic acid, 77.7% caprylic acid, 19.6% capric acid, and 0.8% lauric acid. MCT yields 8.3 calories per gram(6).

The absorption of medium chain triglycerides has been studied in 8 patients with tropical sprue (2 with acute sprue, 4 with sprue in relapse, and 2 in remission). Table I summarizes the relevant descriptive data on each of the patients studied.

Daily fat balance studies were performed first during a period in which a standard steatorrhea test diet (STD) containing long chain animal and vegetable fats was given (7), and continued while substituting isocalorically all the fat in the diet for medium chain triglycerides (MCT diet).*

The following data were obtained for each patient undergoing studies: daily weight, daily determinations of total fat in diet and in stools(8) and weekly determinations of serum cholesterol(9), B-lipoproteins(10), total serum lipids(11), D-xylose excretion (12), and vit. A absorption(13).

Results. The results of the effect of the MCT diet on the mean fecal fat excretion in 8 tropical sprue patients are summarized

* The STD has an average composition of 264 g carbohydrate, 109 g protein and 106 g fat, with a total of 2,434 calories per day. The MCT diet had an average composition of 263 g CHO, 109 g protein and 106 g fat, with a total of 2,469 calories.

TABLE I. Relevant Descriptive Data on 8 Sprue Patients.

Subject	Age	Race	Wt (lb)	Hemoglobin (g %)	VPC (%)	Xylose (g 5 hr)	Vit. A (μg %)	Diagnosis and clinical status
S.C.	39	C	100	9.0	30	.1	30, 26, 36	sprue, untreated, acute
C.M.	63	W	120	10.4	34	.78	56	" treated, relapse
M.L.	72	W	120	12.9	42	.65	74, 82, 134	" remission
M.P.	73	C	141	12.3	39	.77	31, 52, 84	" asymptomatic, remission
R.F.	70	W	144	14.6	46	.15	46, 50, 40	" relapse
M.E.	68	W	130	12.1	36	.30	34, 40, 46	" 20 years, relapse
L.J.	73	W	110	15.0	47	.27	36, 36, 40	" treated, relapse
L.M.P.	40	W	147	11.6	39.5	.46	42, 36, 50	" untreated, acute

in Table II. All patients with steatorrhea showed pronounced response to the MCT diet. Steatorrhea was evident during ingestion of the STD, and subsided during the MCT diet. In those patients in which the STD was given again after a period with MCT, steatorrhea reappeared; it disappeared again with the MCT diet. In most cases fat excretion dropped to normal levels around the third day after beginning the MCT diet. Usually, it took about 3 days for patients to adapt to the MCT diet, some complaining of abdominal discomfort and dizziness. Later, patients exhibited increased appetite. Rapid gain in weight occurred in most patients, especially in those with acute sprue (Table III).

The results of the effect of the MCT diet on serum cholesterol, B-lipoprotein and total serum lipids are presented in Table III. Ingestion of MCT was accompanied by increases in the levels of cholesterol, B-lipoprotein and total serum lipids. When the steatorrhea test diet was reintroduced, the levels of cholesterol, B-lipoprotein and total serum lipids decreased again, and in those cases in which MCT was again tried, a second increase in the 3 serum lipid measurements was observable.

The average apparent coefficient of fat absorption ranged from 74.0 to 93% with the STD, and from 92.3 to 97% with the MCT diet (Fig. 1). Results indicate that patients with steatorrhea attain normal levels of fat excretion if they ingest medium chain triglycerides as the main source of fat in the diet.

Discussion. Previous studies by Asenjo,

TABLE II. Effect of MCT on Steatorrhea in 8 Sprue Patients.

	Steatorrhea test diet				MCT diet				
			Fat excretion (g/day)				Fat excretion (g/day)		
Case	Period	Days	Mean	S.D.	Period	Days	Mean	S.D.	Level of significance
S.C.	I	8	20.1	10.5	II	16	4.6	3.5	$p < .001$
	III	8	14.8	5.8	IV	21	5.2	2.8	$p < .001$
C.M.	I	8	7.5	7.0	II	14	2.8	1.7	$p > .05$
	III	13	8.5	6.2	IV*	10	3.4	.8	$p < .01$
	V	9	7.5	3.8					
M.L.	I	8	5.9	4.8	II	13	6.5	4.2	$p > .5$
	III	9	11.3	7.2	IV	6	3.0	2.5	$p < .025$
M.P.	I	5	7.1	2.4	II	8	4.7	4.0	$p > .2$
R.F.	I	6	20.0	6.5	II	13	4.5	3.6	$p < .001$
	III	8	12.1	5.3	IV	8	6.3	3.2	$p < .025$
M.E.	I	18	20.8	10.2	II	16	6.5	3.5	$p < .001$
L.J.	I	24	20.1	13.2	II	14	5.3	1.5	$p < .001$
L.M.P.	I	20	9.4	7.6	II	10	3.5	1.9	$p < .01$

* Period IV was preceded by a one month interval at home in which patient received MCT as the main source of fat in the diet.

TABLE III. Effect of MCT Diet on Serum Lipids and Body Weight (7 Sprue Patients).

Case	Period of of study	Type of diet*	Cholesterol (mg %)	B-Lipo† (mm ppt)	TSL‡ (mg %)	Weight (lb)
S.C.	I	(STD)	105	1.5	350	100
	II	(MCT)	126	2.9	385	116
	III	(STD)	97	2.0	332	107
	IV	(MCT)	127	3.1	367	111
C.M.	I	(STD)	173	2.8	402	120
	II	(MCT)	198	3.2	586	126
	III	(STD)	171	2.8	367	126
	IV	(MCT)	224	4.0	735	130
	V	(STD)	232	3.2	499	130
M.L.	I	(STD)	113	1.8	368	120
	II	(MCT)	141	2.2	324	120
R.F.	I	(STD)	99	2.1	332	144
	II	(MCT)	127	2.5	376	145
	III	(STD)	106	1.5	315	144
	IV	(MCT)	109	2.0	385	147
M.E.	I	(STD)	117	2.0	350	130
	II	(MCT)	64	3.0	534	130
L.J.	I	(STD)	117	1.8	315	111
	II	(MCT)	215	3.0	385	111.5
L.M.P.	I	(STD)	96	1.7	350	147
	II	(MCT)	167	2.2	437	154

* STD = Steatorrhea test diet; MCT = Medium chain triglyceride diet.
† B-Lipo = Beta Lipoproteins.
‡ TSL = Total serum lipids.

Rodriguez-Molina, and Cancio(7,14), demonstrated that tropical sprue patients exhibit a steatorrhea of exogenous origin, which disappears when a very low fat diet is ingested, and reappears when a steatorrhea test diet is given. The level of endogenous fat excretion is the same for the sprue patient as for the normal control. Therefore, the fat balance technic is useful in the study of fat absorption in sprue patients, since the fecal fat excretion represents mainly unabsorbed dietary fat.

Additional knowledge regarding the influence of fatty acid structure upon fat absorption could be of value in management of the patient with disturbed fat absorption, since the possibility exists that some fatty acids may be absorbed more readily than others by these patients.

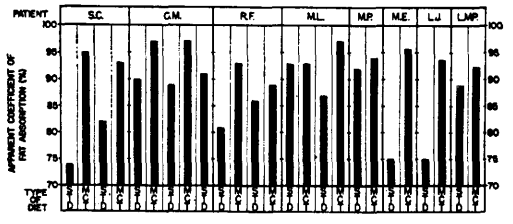

FIG. 1. Medium chain triglyceride absorption in tropical sprue patients, 8 Patients.

Poor absorption of long chain saturated fatty acids was observed by Asenjo, Rodriguez-Molina, and Cancio(15) in 12 tropical sprue patients studied while receiving a steatorrhea test diet consisting of 42.5% saturated and 57.5% unsaturated fatty acids. The same group of patients absorbed 95% of the unsaturated fatty acids. These results are in agreement with the recent findings of Fernández, Van de Kamer and Weijers(16), who studied fatty acid absorption in children with steatorrhea due to celiac disease and suggested that patients with steatorrhea should be fed unsaturated fats.

The adequate intestinal absorption of saturated medium chain fatty acids in tropical sprue patients observed in this investigation agrees with the conclusions of Bloom, Chaikoff and Reinhardt(1), based on studies in animals, that the chain length of a fatty acid is related to the extent of its absorption. Apparently the higher degree of absorption of the medium chain, as compared to the longer chain triglycerides lies in the ability of the

medium chain fatty acids to pass directly into the capillary network that lies between the mucosal lining and the central lacteal, being transported *via* the blood stream from its site of absorption. The capillary endothelium seems to be impermeable to the longer chain triglycerides which are recovered almost completely in chyle in the form of triglycerides.

The predominance of subnormal serum lipid levels in tropical sprue patients seems to be the result of the poor absorption of long chain saturated triglycerides. It was not surprising, therefore, that upon ingestion of medium chain triglycerides, which were normally absorbed, the serum lipid levels in these patients tended to attain normal levels.

Summary. The absorption of medium chain triglycerides (MCT) has been studied in 8 patients with tropical sprue (2 acute, 4 in relapse, 2 in remission). Studies were performed first during a period in which a standard steatorrhea test diet containing long chain animal and vegetable fats was given, and continued while substituting all the fat in the diet for medium chain triglycerides. Normal fat excretion levels were attained by all patients while they were receiving from 80-100 g of medium chain triglycerides in the diet. The average apparent coefficient of fat absorption ranged from 92.3 to 97%. Steatorrhea recurred when the steatorrhea test diet was repeated, and disappeared again when the MCT diet was resumed. Absorption of medium chain triglycerides was accompanied by improved appetite, weight gain, and increased serum lipids. The results of this experiment suggest that medium chain triglycerides may have a place in the management of sprue cases.

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