Original Article

Diet supplemented with MCT oil in the management of childhood diarrhea

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This study was undertaken to determine the effect of medium-chain triglyceride (MCT) oil supplementation on the duration and episodes of diarrhea attacks, and specifically its effect on the clinical manifestations of patients. Seventeen children aged 6 months to 47 months old with a mean age of 19.6 months, suffering from acute diarrhea at the Pediatric Ward of the Philippine General Hospital Medical Center and other neighboring health centers were studied. A double-blind randomized design was employed. Physical and clinical assessment was performed by a physician prior to enrolment in the study. Dietary, anthropometric, and biochemical assessment were undertaken by clinical investigators before and after the supplementation. The subjects were randomly assigned to either the MCT oil- supplemented diet or the non-MCT oil diet. Daily monitoring of food intake and the frequency or episodes of diarrhea attacks was done. Subjects were closely monitored for any possible adverse reactions. The baseline characteristics of the subjects were not significantly different for any of age, height, weight, cholesterol or triglyceride concentrations between the two groups. Nutrient intakes at baseline and during intervention were also not significantly different. There were no differences in cholesterol and triglyceride between the two groups after supplementation. Stool frequencies of the MCT group and the non-MCT group at baseline, after the 6th hr, and at 12th hour, were not different. No subject developed fat malabsorption during the intervention, as assessed with Sudan Black stain. There was statistical significant difference in the rate of weight gain among subjects in the MCT group compared to subjects in the non-MCT group (0.22 ± 0.22 kg/day vs. -.048 ± .26 kg/day, (p= .042). MCT oil may promote weight gain (although what this constitutes in body compositional terms is uncertain) and shows a trend towards shorter duration of intervention among children with acute diarrhea. Limited sample size precludes conclusions on these possibilities. MCT oil did not cause vomiting, dehydration, or fat intolerance. MCT oil did not cause an elevation in cholesterol and triglyceride levels. More studies, with larger sample size, and longer duration will be worthwhile to assess the effect of MCT oil on childhood diarrhea.

Key Words: medium-chain triglyceride oil (MCT oil), diarrhea, children, nutritional status

Introduction

Diarrhea is a common illness and a leading cause of death in young children. In the Philippines, mortality from diarrheal diseases is reported to have decreased from 2.0 to 0.9 per 1,000 infants during the period from 1990 to 1995. Diarrheal disease, however, remains one of the leading causes of infant mortality. According to the 2000 Annual Report of Field Health Service Information System, DOH, diarrhea ranks third in the leading causes of child mortality, with a rate of 16.14 per 100,000 among the 1-4 year old.[1]

Diarrhea is a major cause of malnutrition owing to low food intake during the illness, reduced nutrient absorption in the intestine, and increased nutrient requirements as a result of the infection. Each episode of diarrhea can cause weight loss. The risk of serious malnutrition increases with repeated and prolonged attacks, especially in young children who are already underweight. Diarrhea in malnourished children is more severe, lasts longer and may occur more frequently than in children who are well nourished. Thus, the interaction of diarrhea and malnutrition creates a vicious cycle which, if not interrupted, may lead to the death of the child from malnutrition, diarrhea or another infectious disease. Feeding should therefore be as important part of diarrheal treatment as fluid and electrolytes replacement because 90-95% responds to ORS and feeding alone. It becomes even more expedient in children with already compromised nutritional status because a child with diarrhea can lose weight by up to 100-200 g/day of illness.

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Despite the malabsorption that occurs in diarrhea, studies have shown that this is only partial and considerable absorption of the foods can still take place. About 80-95% of dietary carbohydrate, 50-80% of fats and 50-75% of protein are still absorbed.[2] Thus, it is recommended that feeding be continued during diarrheal episodes. Feeding provides energy and specific nutrients which prevent nutritional damage, helps to retain the intestinal lining, and possibly reduces the risk of persistent diarrhea. Home-made starch-based solutions such as undiluted cereal gruels or some soups, are usually well digested during acute diarrhea and can replace lost fluids. However, they are not rich in energy, thus, other energy-rich foods may also be given to ensure an adequate intake of calories.

One of the ways of increasing nutrient density is the addition of fats which offer a concentrated form of energy that theoretically may prove to be advantageous in diarrhea management to provide maximum energy on one hand and limited absorptive capacity on the other hand. As part of the World Health Organization (WHO) recommendation on feeding during diarrhea, fats or oils should be given to enhance nutrient density of foods of children with diarrhea.

Although no specification as to the type of fats needs to be used, whether LCT (long-chain triglycerides) or MCT (medium-chain triglycerides), the latter may prove to be more advantageous theoretically to be used in a diseased gut as what happens in diarrhea.

MCT oil is a special-purpose food for use as a supportive nutritional therapy. It may be used to increase the calorie value, improve the palatability, digestibility, absorption and transport of a diet indicated for diseases with maldigestion/malabsorption.[3,4]

The effect of MCT on malabsorption states is related to the circumstance that the molecularly small medium chain fatty acids are more easily hydrolyzed by pancreatic lipase and, therefore, more rapidly absorbed than conventional fats.[3]

The rationale for the use of MCT is based on differences in digestion, absorption, transport and catabolism between MCT and long-chain triglycerides (LCT). Although MCT are rapidly hydrolyzed by pancreatic lipase, absorption can occur before hydrolysis. Bile salts and micelle formation are not required for dispersion or absorption of MCT. MCT are transported across the mucosal cell more rapidly than LCT. MCT do not enter the lymph system and are transported through the portal venous system as albumin-bound free fatty acids. They are incorporated into chylomicrons and therefore do not require lipoprotein lipase for oxidation.[4,-6]

Translating this to clinical use, there is no additional penalty imposed on already altered intestinal anatomy and physiology in diarrhea since absorption is more rapid and does not require additional work by intestinal/pancreatic enzymes.

This study was undertaken primarily to compare the therapeutic effects of MCT-supplemented and non-MCT supplemented diets on the duration and frequency of diarrheal episodes. The secondary objective was to determine the safety of giving MCT-supplemented diet as to occurrence of adverse events such as worsening of diarrhea, occurrence of vomiting, abdominal distention and fat malabsorption.

Materials and methods

Subject selection

The study was conducted at the Pediatric Ward of the University of the Philippines-Philippine General Hospital during a one year period. Included were children 6 to 47 months of age, suffering from acute non-bloody diarrhea at least 24 hours but less than 5 days prior to admission with no vomiting nor dehydration and who have not started on oral rehydration at the start of intervention.

Infants were excluded if any of the following conditions were present:

- Absence of bowel sounds;
- Presence of severe dehydration;
- Presence of gross blood in stools;
- Previous intake of anti-diarrheal drugs or antibiotics, multivitamins or mineral supplements which may have laxative effect in the last 24 hours;
- With known sensitivity to MCT oil; and
- Refusal of the parents to sign the informed consent.

Study protocol

A double-blind randomized experimental research design was employed. The study protocol was approved by the Committee on Research Implementation and Development of the University of the Philippines, College of Medicine (CRID, UP-College of Medicine). Written informed consent were obtained from parents of the subjects after the study was explained fully to them.

Physical and clinical assessment was done by a physician prior to inclusion in the study. Dietary, anthropometric, and biochemical assessments, which included cholesterol and triglyceride determinations, were undertaken by clinical investigators right before and after the supplementation. Sudan black was used to detect fat malabsorption and performed within the first hour after admission. Using a table of random numbers, subjects were allocated to either the MCT group or non-MCT group. Both groups received standard treatment in terms of fluid therapy as per WHO protocol. Oral rehydration solution was given on a volume per volume replacement of diarrheic stool (100 ml for children <2 years old and 200 ml for children >2 years old), if the child was not dehydrated or at 75 ml/kg consumed within 4-6 hours, if the child presented with some dehydration (mild and moderate). Feeding was started once the dehydration was corrected The MCT group was given 3 teaspoons MCT oil (124 kcal) equally divided throughout the day and incorporated into the milk formula or regular meals. On the other hand, the non-MCT group was given water packed similarly as the MCT oil and likewise, added to the milk formula or meals. Daily monitoring of food intake were done and the frequency or episodes of diarrheal attacks were recorded. Subjects were closely monitored during periodic intervals for any possible adverse reactions, such as vomiting, diarrhea, and abdominal distention.

Frequency of diarrhea was defined as number of diarrheal episodes per day; duration of diarrhea as, number of days (or hours) from start to cessation of diarrhea. Duration of intervention was defined as the time from start of intervention until the time where there is no stool output

for the last twelve hours or with two consecutive formed stool, whichever comes first. The WHO table of clinical features of dehydration according to severity was used to classify degree of dehydration.[7] The MCT oil utilized in the study was developed by the Industrial Technology Development Institute (ITDI).

The following constituted treatment failures:

a) If total duration of diarrhea exceeded 14 days (from the start of diarrhea and not start of admission)

b) If complications occurred such as:

- worsening of clinical condition (from hydrated to dehydrated state)
- intractable vomiting - 3x per hour
- abdominal distention - an increase of 2 cm from baseline, taken 3 hours post prandial, and on 2 or more occasions;
- increased amount of fecal fat (steatorrhea)

c) If intravenous fluid was required for rehydration

Statistical Analysis

The primary outcomes were analyzed by intention to treat analysis. Results are expressed as means ± standard deviations. All variables recorded at inclusion and thereafter were compared between groups. Statistical Package for Social Science (SPSS) Program was used for the analyses. Data for the two groups were compared by using Mann Whitney Tests. A *p*-value of <0.05 was considered significant.

Results of the study

Population characteristics

The study included 17 children aged 6 months to 47 months with a mean age of 19.6 months. There were six females (35.3%) and 11 males (64.7%). Mean duration of diarrhea before admission was 2.59 (±.79) days. Mean weight on admission was 9.34 (± 1.83) kg, with 13 subjects (76.5%) presenting with no dehydration and only four subjects (23.5%) presenting with mild dehydration. Of the 17 children recruited, eight subjects, representing 47.1% received MCT supplementation while nine or 52.9 % of the subjects were not supplemented with MCT oil. For those who were given MCT and completed the study, 75% were recruited after the second day from onset of diarrhea while the remaining 25% were recruited on their fifth day. Those in the non-MCT group were all recruited on their third day of diarrhea attack. Unfortunately, one subject belonging to the MCT group developed fever and had episodes of vomiting on the second day of recruitment and showed signs of mild dehydration that caused her to be dropped from the study.

Baseline Characteristics

Baseline characteristics of the subjects are presented in Table 1. There were no significant differences between the two groups as to age, height, weight, and frequency of diarrhea before admission, degree of dehydration and serum cholesterol and triglyceride.

Table 2 revealed that among the MCT group the baseline nutrient intake of energy was only 67.3% of the Recommended Nutrient Intake (RENI), while protein was 90.3% of the recommended amount. However, vitamin A and vitamin C intake among the MCT subjects were both beyond the recommended amounts, 118.2% and 122.4% of the RENI, respectively. Among the non-MCT group the baseline intake of subjects exceeded the RENI for protein, vitamin A and vitamin C, except for the energy intake which was only 89.1% of the RENI.

Table 1. Baseline characteristics of subjects

Characteristics	MCT Group (n=7) Mean/SD	Non-MCT Group (n=9) Mean/SD	Mann Whitney Test	*p*-value
Age (months)	23.9 ± 8.8	16.2 ± 12.9	15.0	.08 (NS)
Height (cm)	82.4 ± 6.2	75.0 ± 8.2	14.0	.06 (NS)
Weight (kg)	10.1 ± 1.8	8.9 ± 1.8	19.5	.20 (NS)
Stool frequency before admission	4.3 ± 2.5	4.2 ± 1.5	25.0	.46 (NS)
Degree. of dehydration, no. (%)				
- None	5 (71.0%)	7 (77.8%)	29.5	.78 (NS)
- W/ mild dehydration	2 (29.0%)	2 (22.2%)		
Cholesterol (mg/dl)	125 ± 24.1	128 ± 90.4	7.0	.25 (NS)
Triglyceride (mg/dl)	105 ± 36.0	114 ± 58.3	11.0	.75 (NS)

NS – statistically non-significant

Table 2. Baseline nutrient intake of subjects

	MCT Group (n=7)		Non-MCT Group (n=9)		*p*-value	
Nutrient	Mean/SD	% RENI	Mean/SD	% RENI	Diff. in means	Diff. in RENI
Energy (kcal)	675 ± 657	67.3 ± 62.2	734 ± 510	89.1 ± 75.5	0.49 (NS)	0.43 (NS)
Protein (g)	22.4 ± 25.8	90.3 ± 95.4	24.2 ± 18.2	141 ± 140	0.43 (NS)	0.27 (NS)
Carbohydrate (g)	94.7 ± 85.4	-	92.4 ± 60.3	-	0.32	-
Fat (g)	21.9 ± 22.5	-	29.7 ± 22.9	-	0.32	
Vitamin A (RE)	473 ± 462	118 ± 116	788 ± 562	197 ± 141	0.15 (NS)	0.15 (NS)
Vitamin C (mg)	36.7 ± 45.2	122 ± 151	55.7 ± 84.9	186 ± 283	0.96 (NS)	0.96(NS)

Note: No RENI for carbohydrate and fat

Table 3. Comparison of initial and final weight measurements of subjects

Weight	MCT Group Mean/SD	Non-MCT Group Mean/SD	Mann Whitney Test	*p*-value
Initial weight (kg)	10.1 ± 1.8	8.91 ± 1.80	19.5	.20 (NS)
Final weight (kg)	10.3 ± 1.72	8.88 ± 1.76	16.0	.10 (NS)
Mean weight change	0.19 ± 0.19	-0.03 ± 0.20	13.0	.047*

* indicates borderline significance

Table 4. Energy, carbohydrates, protein, fats, vitamin a and vitamin C intakes at baseline, at 6th hour and 12th hour during intervention

Nutrient	Mean nutrient intakes						*p*-values	
	Baseline	MCT 6th hr	12th hr	Baseline	Non-MCT 6th hr	12th hr	MCT	Non-MCT
	1	2	3	1	2	3	1 vs 2	1 vs 2
Energy (kcal)	675 ± 657	710 ± 426	846 ± 21.2	734 ± 510	743 ± 686	807 ± 709	.73	.86
CHO (g)	94.7 ± 85.4	78.4 ± 9.3	125 ± 24.7	92.4± 60.3	92.6 ± 83.8	103.4 ± 83.6	1.0	.68
Protein (g)	22.4 ± 5.8	23.9 ± 22.7	66.3 ± 60.3	24.2 ± 18.2	22.9 ± 24.2	25.2 ± 25.5	.73	.59
Fat (g)	21.8 ± 22.5	32.0 ± 21.4	30.1 ± 4.4	29.7 ± 22.9	33.9 ± 29.6	34.2 ± 29.8	.03*	.68
Vit. A (RE)	473 ± 462	539 ± 411	566±598	788 ± 562	1842 ± 2735	877 ± 649	.24	.07
Vit. C (mg)	36.7 ± 45.2	45.1 ± 47.2	58.5 ± 54.4	55.6 ± 84.9	66.0 +106	96.3 ± 105	.09	.16

*significant at p=.05. Note: There are not enough valid cases to perform the 24th and 48th hr.

Table 5. Clinical characteristics of subjects

Characteristics	MCT Group (n=7)	Non-MCT Group	Mann Whitney Test	*p*-value
Discharge weight (kg)	10.3 ± 1.7	8.9 ± 1.8	16.0	0.10 (NS)
Weight change				
▪ No. (%) with weight gain	5 (71.4)	2 (22.2)		
▪ No. (%) with weight loss	1 (14.3)	5 (5.6)	17.5	0.11 (NS)
▪ No. (%) with same weight	1 (14.3)	2 (22.2)		
Rate of weight gain (kg/day)[1]	0.22 ± .22	-.05 ± .07	12.5	.042*
Mean weight change (kg)	0.18 ± 0.19	-0.33 ±.20	13.0	.047*
Mean duration of intervention (days)	1.14 ± 0.63	1.33 ± 0.83	28.0	.69
Vomiting, No. (%)				
▪ with vomiting	0	0	27.0	0.26 (NS)
▪ without vomiting	7 (100.0%)	9 (100.0%)		
Stool frequency				
▪ 6th hour	2.14 ±1.8	2.44 ± 1.3	22.0	.30 (NS)
▪ 12th hour	2.0 ± 1.0	1.86 ± .9	10.0	.90 (NS)
Duration of diarrhea (days)	3.43 ± 0.93	3.56 ± 1.31	31.5	1.00 (NS)

*significant at p=.05. [1] Rate of weight gain/loss = $\frac{\text{mean weight change}}{\text{duration of intervention}}$

Outcome of patients

Weight gain

A minimal weight gain of about 0.2 kg was observed among the MCT group while a weight loss of .03 kg was observed among the non- MCT group (Table 3). There were no significant differences in the initial and final weight measurements of both groups.

Nutrient intake during intervention

Mean difference in energy and nutrient intakes at baseline and during intervention (at 6th hr, at 12th hr.) between the MCT and non-MCT groups showed non-significant differences.

Clinical characteristics

The MCT supplemented group was heavier (10.3 kg versus 8.9 kg), had greater proportion of weight gain, lesser proportion of weight loss (14.3% versus 55.6%) and with no weight change (14.3% vs. 22.2%) compared to the non-MCT supplemented group (Table 5). There was a

Table 6. Biochemical test results of subjects after intervention

Biochemical variables	MCT Group (n=7)	Non-MCT Group (n=7)	*p*-value
Cholesterol (mg/dl)	122 ± 30.4	110 ± 44.5	.42 (NS)
Triglycerides (mg/dl)	82.4 ± 17.8	130 ± 83.0	.84 (NS)
Change from admission to discharge			
▪ Cholesterol	3.1 ± 9.0	18.5 ± 48.6	.75 (NS)
▪ Triglyceride	22.8 ± 33.2	-15.5 ± 69.7	.35 (NS)

(negative values indicate increase in values)

Table 7. Distribution and mean number of days enrolled by study group

Days enrolled in the study	MCT Group		Non-MCT Group		Total
	No.	%	No.	%	
≤ 1 day	5	71.4	6	66.7	11
2 days	2	28.6	2	22.2	4
3 days	0	0	1	11.1	1
Total	7	100.0	9	100	16
Mean (± SD)	1.14 ± 0.63		1.33 ± 0.83		1.25 ± 0.73

Mann Whitney= -.393, p=.694 (no significant difference)

statistical significant difference in the rate of weight gain among subjects in the MCT group compared to subjects in the non-MCT group (0.22 ± 0.22 kg/day vs. -.048 ± .26 kg/day), (*p*=.042).

The mean stool frequencies of both the MCT group and the non-MCT group after the 6th hr, and 12th hour, are comparable. Likewise, no significant differences were observed in duration of diarrhea between the two groups.

No subject developed fat malabsorption during the intervention, as determined with Sudan Black stain.

Biochemistry

Table 6 shows the biochemical results of subjects which revealed no significant differences in cholesterol or triglycerides between the MCT group and non-MCT group. Using the Mann Whitney test, there was also no-change from admission to discharge in the serum cholesterol and triglyceride values for either group or between the 2 groups.

Table 7 shows the length of stay after inclusion in the study. About ¾ (71.4%) of the MCT group completed the study in one day or less compared to about 2/3 (66.7%) in the non-MCT group. None of the MCT group subjects went beyond 2 days of enrolment in the study.

The MCT group had a lower mean of 1.14 days compared to the non-MCT group which showed a mean of 1.33 days in the study. However, the Mann Whitney statistic showed no significant differences (*p*=0.694) between the two groups.

Discussion

Medium-chain triglycerides (MCT) are fats with an unusual chemical structure that allows the body to digest them easily. The molecular weight of MCT is smaller than the molecular size of long-chain triglycerides (LCTs). This facilitates the action of pancreatic lipase. Consequently, MCTs are hydrolysed both faster and more completely than LCTs.[5] Medium chain fatty acids are transported to the liver via the portal vein versus the lymphatic route taken by the long chain fatty acids. Medium chain fatty acid are more rapidly oxidized nearly approaching like a carbohydrate fuel.[8] and appear less conducive to fat deposition when compared to long chain fatty acids. Owing to their unique metabolism, medium-chain triglyceride oils have proven to be an important source of energy in a variety of clinical conditions. The objective of this study was to determine the effect of MCT oil supplementation on the duration and frequency of diarrhea attacks, and specifically the effects of MCT and non-MCT supplemented diets on the clinical manifestations of children with diarrhea.

There were no significant differences between the 2 groups, in terms of age, duration of diarrhea and stool frequency. With respect to weight changes from admission to discharge, the MCT group was observed to have a small weight gain compared to the non-MCT group, but not statistically significant. Since the dietary intake during intervention was not different between the 2 groups, it may be surmised that the possible weight gain and its faster advent might be due to MCT oil supplementation.

There were no observable differences in te biochemical indices assessed. However,if anything, a slight decrease in the triglyceride levels was observed among the MCT group. This contrasts with the recognized metabolic response to injury of various kinds, in people with normal intestinal absorption, where a hypertriglyceridemic response is seen and also observed with MCT feeding. [9-12]

Therapeutic use of MCT oil has been limited due to the occasional occurrence of mild gastrointestinal symptoms, including crampy abdominal pain, nausea and diarrhea. Reportedly, these symptoms can be ameliorated with cautious administration of MCT oil. The oil should be introduced in small amounts, given at room temperature, diluted with an equal volume of water or fruit juice, and taken slowly. [13] In this study, MCT oil was administered equally throughout the day, incorporated into the milk formula or meals, with a dosage of 15 ml. per day, which

was on the average 46.8% of the total fat calorie. During the course of MCT oil administration, no significant clinical symptoms warranted the discontinuation of therapy.

In a case report on the supplementation with MCT oil together with a low fat diet, it was shown that MCT oil was effective in alleviating the diarrhea and hypoproteinemia.[14]

In the study of Wanke and co-workers, a reduction of diarrhea and malabsorption among patients with human immuno deficiency virus given MCT was noted. Similar to this study, potential adverse reactions were prevented, possibly because the MCT was within the recommended upper limit of 40% of total calories from fat. [15]

Conclusion

The present study, using MCT oil in childhood diarrhea may allow weight gain and shorten the required duration of intervention MCT oil did not cause vomiting, dehydration or fat intolerance. MCT oil did not elevate serum lipid concentrations.

Recommendation

Since little information is available on the effect of MCT oil in the treatment of diarrhea, more extensive studies with it and with larger sample size are required. The trend towards weight gain and the need for shorter intervention may not only decrease morbidity but also decrease the costs of hospitalization among children with acute diarrhea.

CCT conceptualized and led in the implementation and writing of the manuscript; AJC performed data collection and processing, and drafted technical paper; JMR acted consultant to the project and edited final manuscript; RSC assisted in biochemical screening and data collection; MPR performed laboratory analyses; CLO acted as statistical consultant, and LCH prepared the MCT oil for the project.

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Original Article

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飲食中補充 MCT 油處理小孩腹瀉

此研究評估在腹瀉期間補充中鏈脂肪酸(MCT)油脂的效應，特別針對病人臨床表現的效應。17 名，於菲律賓總醫院醫學中心小兒科病房及其鄰近的健康中心就診的急性腹瀉兒童，年齡 6 至 47 個月，平均年齡 19.6 個月。採用雙盲隨機設計。在納入研究前，由一名醫生進行身體及臨床評估。在補充之前及之後，由臨床研究者進行飲食、體位測量及生化評估。研究對象隨機分派進入 MCT 油脂補充飲食或非 MCT 油脂補充飲食。每日監測飲食攝取及腹瀉的頻率。任何可能會出現的副作用均接受嚴密的監控。兩組在研究開始之年齡、身高、體重、膽固醇或是三酸甘油酯濃度等基本特性均沒有顯著差異。研究開始及介入其間的營養素攝取也沒有顯著差異。在補充 MCT 油脂後，兩組的膽固醇及三酸甘油酯沒有不同。MCT 組與非 MCT 組在研究開始、6 小時及 12 小時候排便的次數沒有差異。採用蘇丹染色評估，沒有研究對象在介入期間有脂質吸收不良的現象。MCT 組比起非 MCT 組的研究對象在體重增加率上達統計顯著差異(0.22 $\pm$ 0.22 kg/day vs -.048 $\pm$ .26 kg/day), (p=.042)。MCT 油脂可能促進體重增加(雖然這個成分在體組成的名詞還不確定)，且在急性腹瀉兒童短期介入呈現趨勢。因為受限於樣本數，使得無法下結論。MCT 油脂不會引起嘔吐、脫水或脂質耐受不良。MCT 油脂也不會造成膽固醇及三酸甘油酯的升高。較多較大樣本及較長的時間之研究，將值得用以評估 MCT 油脂在兒童腹瀉的效應。

關鍵字：中鏈三酸甘油酯(MCT 油脂)、腹瀉、兒童、營養狀況。