# Treatment of Childhood Epilepsy with a Medium Chain Triglyceride Ketogenic Diet (MCTKD): A Case Report

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## ABSTRACT

Our case involves a nine-year-old little girl with a birth history of the gestational age of 38 weeks, body weight of 3800g as well as a medical, history cerebral palsy due to bacterial meningitis which can lead to Guillain-Barre' Syndrome (GBS) and, epilepsy controlled with antiepileptic drugs. The patient complained of frequent seizure episodes, averaging 3-4 seizures per day. We suggested a, ketogenic diet and further surveillance. The medium-chain triglyceride ketogenic diet (MCTKD) is a special high-fat, low-carbohydrate diet that has been reported to help control seizures in patients with epilepsy. The ketogenic diet "ratio" is a 3:1 ratio of fat to carbohydrate and protein grams combined. Her seizure daily episodes were reduced to 3 or 4 times per week and their durations were shortened. The diet improved her condition has significantly, though total seizure control was not achieved. (J Med Health. 2020;9(3):127-135)

# Key words : Guillain-Barré syndrome, Medium chain triglyceride, Ketone body, Epilepsy

## Introduction

Epilepsy is a neurological condition that (affects the brain and nervous system, and most persons with

this condition tend) to have seizures that start in the brain.<sup>[1]</sup> Most seizures in childhood cannot be definitely attributed to a specific cause. Children diagnosed with epilepsy face considerable challenges. Based on various

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studies, approximately 0.5% of the world's population is reported to be affected by active epilepsy.<sup>[2,3]</sup>

Antiepileptic drugs (AED) are the main form of treatment for epilepsy. Although many AED's have been developed, approximately one-third of epilepsy patients are not responsive to them.<sup>[4]</sup> One increasingly used noninvasive treatment for children is the ketogenic diet. The ketogenic diet is a high-fat, adequate-protein, and low-carbohydrate diet that has been used in medicine to treat difficult-to-control (refractory) epilepsy in children.<sup>[5]</sup>

Most dietary fat is made of molecules called longchain triglycerides (LCTs). However, medium-chain triglycerides (MCTs) fat can produce ketones more easily than LCTs fat, and often do not require carnitine by the body (or as a supplement) to break down these fats into ketones. This means that in the MCT diet, less total fat is needed, allowing more carbohydrate and protein to be included in the regimen. It may also be more beneficial to a child's or an adult's cholesterol and triglycerides than an LCT diet.<sup>[6]</sup> In a 3:1 ketogenic diet, about 75% of the calories come from fat (50-60% MCT oil) and 25% comes from protein plus carbohydrate. Based on tolerance and seizure control, any percentage of MCT oil can be used, just as the classic diet can be adjusted with different diet ratios, for example, 4:1, 3:1, etc. [7]

Several theories have been advanced to explain the antiseizure activity of high fat ketogenic diets but none has yet to receive broad acceptance.<sup>[8]</sup> Animal studies suggest MCTKD has a positive effect in reducing brain cerebral excitability in young animals, <sup>[9]</sup> and the acute anticonvulsant property of caprylic acid (the main component of MCTKD) may be beneficial for seizures and increase overall clinical control.<sup>[10]</sup> This case shares a successful experience using an MCT ketogenic diet to treat childhood epilepsy.

#### **Case Report**

A 9-year-old little girl with birth history of gestational age 38 weeks, and body weight 3800g, and medical history of cerebral palsy due to bacterial meningitis and epilepsy under antiepileptic control visited our hospital complaining of frequent seizure episodes averaging of three-four per day. She had been treated with multiple antiepileptic drugs resulting only in short periods of free from seizures. She declined epilepsy surgery or vagal nerve stimulation and preferred noninvasive approaches. Therefore, we suggested that she try the ketogenic diet and remain under surveillance.

The ketogenic diet is supervised by a dietician who monitors the child's nutrition and can teach parents and the child what can and cannot be eaten. Typically the diet is started in the hospital. The child begins by fasting (except for water) under close medical supervision for 24 hours. When urine ketones appear above 2+, the diet is then started, either by slowly increasing the calories or the ratio (Fig. 1).

The patient's body height (BH) was 130cm (15-50th percentile), and body weight (BW) 40kg (85-97th percentile). The TEE (total energy expenditure) was set at 1500 kcal/ protein 40g/day (Table 1). We introduced 100% MCT oil in liquid form. The MCT ketogenic diet recommends that 50 to 60 percent of the fat intake in the diet comes from MCT fats, gradually increased from 500 kcal to 1500 kcal per day and adjusted according to the situation. We observed that our patient maintained good nutritional status, her albumin improved from 3.8 to 4.1 (g/dl) and Hb (Hemoglobin) improved from 13.3 to 15 (g/dl) (Fig. 2).

The ketogenic diet "ratio" is a 3:1 ratio of fat to carbohydrate and protein grams combine. In this study, the Medium Chain Triglyceride (MCT) Ketogenic Diet was made up of 50-60% MCT, 15% carbohydrate, 10% protein, and 75% total fat. MCT is gradually increased to achieve maximum seizure control. The patients' clinical condition and the effectiveness of the treatment were assessed at admission and follow-up during the inpatient and our outpatient clinics. When initiating the diet, if diarrhea or vomiting occurs, the MCT is lowered by 10% and LCT is increased by 10% for the next feed until the patient is able to tolerate the diet.

Prior to treatment, our patient had reported daily seizures averaging 3-4 per day though she was receiving, an adequate dosage of depakine lyophilized injection, depakine chrono, and chloral hydrate. After the dietary intervention, the onset of epilepsy was reduced to three or four times a week and, the duration seizures were shortened (Fig. 3). There were no anticonvulsants (seizure medicines) that should be stopped while on the diet. The diet led to significant improvement in her condition, though total, seizure control was not achieved.

#### Discussion

In this case study, we report a patient with drugresistant epilepsy who experienced marked seizure reduction after the addition of MCT oil to her regular diet. The efficacy of the ketogenic, modified Atkins, and low glycemic diets has been verified in several studies.<sup>[11]</sup> Because the medium chain triglycerides (MCTs) are more ketogenic than LCTs, Huttenlocher et al.<sup>[12]</sup> created the MCT oil diet, which permits greater amounts of carbohydrate and protein, and therefore allows a more flexible meal plan.

The classic therapeutic ketogenic diet was developed for the treatment of pediatric epilepsy in the 1920s and was widely used into the next decade, and it contains a 4:1 ratio by weight of fat to combined protein and carbohydrate, so most dietary fat is made of molecules called long-chain triglycerides (LCTs). Based on current evidence, MCTs are more ketogenic than LCTs. A 4:1 ratio is stricter than a 3:1 ratio and is generally more effective but harder for patients to adhere to. Because the successful treatment of KD largely depends on the adherence of patients, cooperation among physicians, dieticians, family, and patients is of the utmost importance.<sup>[13]</sup> Taking into consideration the need for long-term care and diet compliance, we used a 3: 1 ratio.

The effectiveness of adjuvant MCT for refractory epilepsy was supported with the patient improving significantly effective after only 20 days of treatment. Furthermore, Wang YS and Hsieh MY et al., found 7 (13.2%) their patients became seizure-free after 1 month of the MCT ketogenic diet, and 28 (52.8%) achieved a >50% improvement in seizure control.<sup>[14]</sup> These results are promising and indicate that the clinical efficacy of an MCT ketogenic diet can be seen early. Ivy et al. observed that 100% of participants in their study experienced gastric distress (cramping and diarrhea) with dosages of 50 and 60g MCT, with only small GI

	B (BS)	L (LS)	D (DS)	
Whole milk	1/2 EX			
Vegetable	1/2 EX	1/2 EX	1EX	
Cereal	1EX	1EX	1EX	
Meat	1EX	1EX	2EX	
MCTs oil	20g	20g	22g	
Cooking oil (LCTs)	13g	13g	12g	

# Table 1. Meal plan: total energy expenditure (TEE): 1500 Kcal/day (protein 10% (40g), carbohydrate 15%,fat 75% (MCT 50-60%).

B (BS): breakfast and breakfast snacks; L (LS): lunch and lunch snacks; D (DS): dinner and dinner snacks; MCTs: medium-chain triglycerides; LCTs: long-chain triglycerides; EX: food exchange.

• Three days before the admission to the diet adjustment: avoid being eaten with fruit, dessert, milk, biscuits.

- Typically the diet is started in the hospital.
- The child begins by fasting (except for water) under close medical supervision for 24 hours.
- When KB (ketone body)++ is induced in the body, it begins to intervene in MCT ketogenic diet, which is gradually increased from 500 kcal to 1500 kcal per day and adjusted according to the situation.
- The ketogenic diet "ratio" is the ratio of fat to carbohydrate and protein grams combined and a 3:1 ration is used.

• Maintain urine KB++

• Education MCT Ketogenic diet skill for discharged.

Figure 1. Flow chart of the experimental design.



(A) albumin improved from 3.8 to 4.1 (g/dl); OPD: outpatient department.



(B) Hb (Hemoglobin) improved from 13.3 to 15 (g/dl); OPD: outpatient department.

Figure 2. Follow on MCT ketogenic diet and maintain good nutritional status. (A) serum albumin (above); (B) hemoglobin (below).



(A) seizure times and urine ketone body; OPD: outpatient department.



(B) body weight (BW) change; OPD: outpatient department.

Figure 3. After dietary intervention, the onset of epilepsy is from 3 to 4 times a day, which is reduced to 3 to 4 times a week, and the duration of action is reduced. (A) seizure times and urine ketone body (above); (B) body weight change (below).

effects noted at 30g,<sup>[15]</sup> while constipation and other gastrointestinal effects result from reduced food volume, increased fat intake, or reduced fiber intake.<sup>[16,17]</sup> In our case, there was a short-term diarrhea on the ketogenic diet in the first week, but this was improved after first reducing the MCT oil ratio and then gradually returning it to the original recommended ratio. In the second week, the patient had some constipation and was encouraged to increase her exercise and drink enough water to promote bowel movements.

In conclusion, epilepsy is a complex set of brain disorders, and epilepsy in childhood is often associated with reduced general intellectual functioning and specific cognitive impairments. One increasingly used noninvasive treatment for children is the ketogenic diet. Studies indicate that MCTs are essentially nontoxic,<sup>[18]</sup> and thus families may choose to keep their child on the ketogenic diet for many years in these situations.

# **Conflicts of Interest Statement**

The authors declare no conflicts of interest.

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#### References

 Engel J, Pitkänen A, Loeb J, Dudek E, Bertram E, Cole A: Epilepsy biomarkers. Epilepsia 2013;54:61-9.

- Forsgren L, Beghi E, Oun A, Sillanpää M: The epidemiology of epilepsy in Europe - a systematic review. Eur J Neurol 2005;12:245-53.
- Wang WZ1, Wu JZ, Wang DS, et al.: The prevalence and treatment gap in epilepsy in China: an ILAE/IBE/WHO study. Neurology 2003;60:1544-5.
- Altshuler LL, Devinsky O, Post RM, Theodore W: Depression, anxiety, and temporal lobe epilepsy. Laterality
  of focus and symptoms. Arch Neurol 1990;47:284-8.
- Kossoff EH, Krauss GL, McGrogan JR, Freeman JM: Efficacy of the Atkins diet as therapy for intractable epilepsy. Neurology 2003;61:1789-91.
- Liu YM, Wang HS: Medium-chain triglyceride ketogenic diet, an effective treatment for drug-resistant epilepsy and a comparison with other ketogenic diets. Biomed J 2013; 36:9-15.
- Liu YM: Medium-chain triglyceride (MCT) ketogenic therapy. Epilepsia. 2008;49:33-6.
- Hartman AL, Gasior M, Vining EP, Rogawski MA: The neuropharmacology of the ketogenic diet. Pediatr Neurol 2007;36:281-92.
- 9. de Almeida RO, da Rocha AT, de Oliveira SL, et al.: Effects of short-term and long-term treatment with medium-and long-chain triglycerides ketogenic diet on cortical spreading depression in young rats. Neurosci Lett 2008;434:66-70
- Wlaź P, Socala K, Nieoczym D, et al.: Anticonvulsant profile of caprylic acid, a main constituent of the mediumchain triglyceride (MCT) ketogenic diet, in mice. Neuropharmacology 2012;62:1882-9.
- Kossoff EH: Nonpharmacological approaches: diet and neurostimulation. Handbook of Clinical Neurology 2013; 111:803-8.
- Huttenlocher PR, Wilbourn AJ, Signore JM: Medium-chain triglycerides as a therapy for intractable childhood epilepsy. Neurology 1971;21:1097-103..

- Kim JM: Ketogenic diet: Old treatment, new beginning. Clin Neurophysiol Pract. 2017;2:161-2.
- Wang YS, Hsieh MY, Hung PC, et al.: Medium-chain triglyceride ketogenic diet for drug resistant epilepsy in Taiwan: A prospective study in a single center. Neurology Asia 2016;21: 341-7.
- Ivy JL, Costill DL, Fink WJ, Maglischo E: Contribution of medium and long chain triglyceride intake to energy metabolism during prolonged exercise. Int J. Sports Med. 1980;1:15-20.
- Kang HC, Chung DE, Kim DW, Kim HD: Early-and lateonset complications of the ketogenic diet for intractable epilepsy. Epilepsia. 2004;45:1116-23.
- Kang HC1, Kim YJ, Kim DW, Kim HD: Efficacy and safety of the ketogenic diet for intractable childhood epilepsy: Korean multicentric experience. Epilepsia. 2005;46:272-9.
- Traul KA, Driedger A, Ingle DL, Nakhasi D: Review of the toxicologic properties of medium-chain triglycerides. Food Chem Toxicol. 2000;38:79-98.

## 個案報告

# 中鏈三酸甘油脂生酮飲食治療

# 兒童癲癇:個案報告

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### 摘 要

一位9歲小女孩、出生胎齡為38週、出生體重3800g,因細菌性腦膜炎導致腦癱,造成 格林-巴利綜合症候群並使用抗癲癇藥控制。由於癲癇發作頻繁,平均每天發作3-4次,建議 病患使用生酮飲食並進行監測。中鏈三酸甘油酯生酮飲食(MCTKD)是一種特殊的高脂肪低 碳水化合物飲食,有助於控制癲癇患者的癲癇發作,飲食中的脂肪與碳水化合物和蛋白質克 的比例採用3:1的比例。病患癲癇發作由每天發生3至4次,改善至而每週3至4次,並且縮短 癲癇發作時間。中鏈三酸甘油酯生酮飲食有明顯但並非完全控制癲癇發作。

關鍵詞:格林-巴利綜合症候群(Guillain-Barré syndrome)、中鏈甘油三酸酯(Medium-chain triglycerides)、酮體、癲癇

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