Ketogenic Diets: Modifications to Manage Seizure Disorders

Yeou-Mei Christiana Liu
M.Sc., RD, RDN,CHES

The Hospital For Sick Children
Toronto, Canada

About the presenter

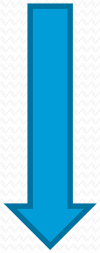
Christiana Liu, MSc, RD, RDN, CHES is a dietitian at the Hospital for Sick Children in Toronto, Canada. She has been a dietitian practicing in the ketogenic diet for almost 20 years. She works with all variants of the ketogenic diet but her specialty is the MCT ketogenic diet. She has published extensively and has spoken nationally and internationally on the ketogenic diet.

The opinions expressed here are my own views and not those of any of the sponsors of this event.

Les opinions exprimées ici reflètent mon point de vue personnel, et non celui des commanditaires.

Determining Candidates for the Ketogenic Diet

- Initial screen: Intractable Epilepsy
- Metabolic screen: No contraindications
- Swallow evaluation: Passed or feeding tube
- Additional risks: Assessed and able to resolve



Determine which KD is appropriate

Information adopted from C Liu, Nutrition Care Manual, Academy of Nutrition and Dietetics, 2012-2017

created by Christiana Liu

Which KD to Start

Classic KD	MCT KD	LGIT	MAD
• All candidates • G-tube/G-J tube fed • Younger than 1 year old	• Not on valproate/Epival® medication • No chronic diarrhea • Older than 1 year old • Oral eater • Teenager or children with larger appetite • Picky eater • Finances allow the cost of MCT oil	• Limited dietitian resources • Family does not want to weigh foods • Oral eater	• Older children/ teenager/adults • Family does not want to weigh foods • Likes a lot of protein foods • Limited dietitian resources • Oral eater

Epival is a registered trademark of Abbott and not affiliated with Nutricia North America.

Information adopted from C Liu, Nutrition Care Manual, Academy of Nutrition and Dietetics 2012-2017

created by Christiana Liu

Classic Ketogenic Diet Modifications

1. Modify diet ratio according to each individual's tolerance.
2. Diet ratio can increase or decrease by 0.5:1 or 0.25:1 ratio, it can be for all meals or for one or two meals based on time of the seizures and ketone level.
3. Make sure patient's urine ketone do not exceed 16 mmol/L (160 mg/dl)
4. For oral intake, adding commercial formula, i.e. KetoCal® 4:1 LQ, KetoVie™ can be one, two or all meals

created by Christiana Liu

Classic Ketogenic Diet Modifications

5. Add MCT oil - Can be at one, two or all meals
6. Commercial powder ketogenic diet formula, such as KetoCal® powder to bake snacks to make meals more interesting.
7. For g-tube feed: adding emulsified MCT oil, i.e. Liquigen®, Betaquik®.
8. Calorie adjustments
   - Weight loss
   - Weight gain

Betaquik is a registered trademark of Vitaflo/Nestlé Nutrition and not affiliated with Nutricia North America.

created by Christiana Liu

Case #1

3.5 yr old girl with myelomeningocele, spina bifida, severe gastroesophageal reflux with generalized tonic-clonic seizure: 10-20/day. GJ tube, with fundoplication

- 6 months after fundoplication start 3:1 ratio classic KD (KetoCal® formula with CHO and protein modules)
  - >50% seizure reduction after 1st month on diet
- 2 months post diet: PM snack: 3.25:1 ratio
- 5 months post diet: 1st,2nd, 4th feeds: 3.75:1 ratio, 3rd feed: 3:1 ratio
- 13 months post diet: 4:1 ratio
  - Seizure control: 70% improvement

Why were the ratio changes made?

created by Christiana Liu

Medium-chain triglycerides (MCTs)

- C6-C12
- Requires little or no pancreatic lipase for digestion
- Quickly hydrolyzed into medium-chain fatty acids (MCFA)
- Decanoic acid (C10) and Capric acid (C8) function as anticonvulsants
- Fast absorption
- Efficient ketone resource for energy

MCT Ketogenic Diet

- A variant of the classic KD
- Allows more carbohydrate, thus more palatable than the classic KD
- Efficacy was excellent, similar success rate to that achieved on the classic KD

MCT Ketogenic Diet

Food Groups:

- Milk
- Vegetables/Fruits
- Protein
- Starch
- Oil/Butter
- MCT Oil

MCT KD

- Start 1/3 feeds (1/3 daily calories)÷6 times, 2-3 hours between feeds via milk or soy milkshake (recipe to follow)
- Progress to 2/3 feeds (2/3 daily calories)÷6 times via milk or soy milkshake or solid foods
- Progress to solid foods full feeds, 6 times per day
- Start most patients at 50% MCT diet or lower percentage MCT for younger children
- MCT oil divided evenly among the 6 feeds
- Any intolerance, lower 10% of MCT immediately for the following feed

Diet Calculations

- Daily Calorie: Estimated Energy Requirement (EER) according to age, sex, activity/stress factor
- Protein: Dietary Reference Intake (DRI) according to age
- Example:

1112 Kcal 60% MCT

60% MCT: 80.4 gm

11% Fat: 13.6 gm

19% CHO: 52.8 gm

10% Protein: 27.8 gm

MCT Ketogenic shake

Milkshakes (Full Day):

- **810.9 gm Skim Milk**
- **13.4 gm White Sugar**
- **13.6 gm Canola Oil**

Mix all ingredients and divide into 6 equal portions for the day. To each portion, add 13.4 gm of MCT Oil for each feed.

Diet Calculations

1 Starch Exchange

15 g carbohydrate

2 g protein

0 g fat

<u>The following are equal to 1 starch exchange:</u>

Bread: whole-wheat, cracked-wheat, rye, enriched white, flour tortilla - 30 g

Bagel, English muffin, bun or dinner roll, pita, rice cake - 30 g

Soda crackers - 20 g

Cereals: Ready-to-eat unsweetened (Shredded Wheat™, Corn Flakes®, Rice Krispies®, Cheerios®, Puffed wheat)

Dry, cooked cereal (e.g., oatmeal) - 20 g

created by Christiana Liu

1112 Kcal MCT Ketogenic Diet

Exchange	Carbohydrate	Protein	Fat
Starch: 1 1/3	20	2.7	0
Fruits/Vegetables: 1 ½	15	1.5	0
Milk (skim): 1 ½	18	12	0
Protein (lean): 1 ½	0	10.5	4.5
Fat: 2	0	0	10
Total in gram	53	26.7	14.5
MCT/day: 80.4 gm			

1112 Kcal MCT Ketogenic Diet

	B'fast	Sn1	Lunch	Sn2	Dinner	Sn3
Starch	1/2		1/3		1/2	
Fruits/ Vegetables	1/2		1/2		1/2	
Protein	1/2		1/2		1/2	
Milk(skim)	1/4	1/4	1/4	1/4	1/4	1/4
Fat	1/2		1/2		1	
MCT oil	13.4 g	13.4 g	13.4 g	13.4 g	13.4 g	13.4 g

created by Christiana Liu

MCT KD Complications

- **Diarrhea:** lower percentage MCT oil for MCT KD during diet initiation stage. During diet maintenance: may need to hold diet, use diluted electrolyte solution (i.e. ½ strength Pedialyte®)

- **Vomiting:** treated with odanestron, lower MCT oil for MCT KD during diet initiation stage. During diet maintenance: need to hold diet use diluted electrolyte solution (i.e. ½ strength Pedialyte®)

- **Dehydration:** treated with diluted electrolyte solution (i.e. ½ strength Pedialyte®) at home or IV saline in hospital

created by Christiana Liu

MCT Ketogenic diet

created by Christiana Liu

MCT Ketogenic Diet Modifications

1. Modify MCT dosage by increasing MCT oil by 0.1 gm – 1.0 gm per feed up to next 10% MCT diet according to each individual's tolerance.
2. Increase MCT oil for all meals or one meal based on time of the seizures and urine ketone level.
3. Make sure patient's urine ketone does not exceed 16 mmol/L (160 mg/dl) and patient does not have diarrhea or vomiting.

MCT Ketogenic Diet Modifications

4. Lower carbohydrate foods.
5. Consider adding commercial keto formula, i.e. KetoCal® 4:1 LQ, KetoVie™ at one, two or all meals
6. Keto powder for varieties of the baked snacks to make meals more interesting, i.e. KetoCal® powder.
7. Calorie adjustments
   - Weight loss
   - Weight gain

Case #2

- 3.5 yr old boy
- Dx: Doose syndrome, generalized tonic-clonic seizures and myoclonic, daily (>100) drop seizures,
- Diet: picky eater, started on 40% MCT ketogenic diet
- Urine ketone: AM: 4, PM: 8 mmol/L
- Not able to increase MCT oil as GI intolerance – diarrhea
- 3 months: increased long chain fat, lower carbohydrate foods, 25% seizure improvement
- 6 months: start adding KetoCal® 4:1 LQ ½ drink box at bedtime - increased MCT by 0.1 gm/feed only one feed per day, urine ketone stable >8 mmol/L.
- 10 months: KetoCal® 4:1 LQ ½ drink box per meal x 6 meals per day.
- 13 months: Seizure-free
- Patient with increased caloric intake – recommended increasing exercise to help manage weight – patient is running children's marathon
- 4 years seizure-free, started KD diet weaning this July.

Case #3

- 5 yr old girl
- Dx: multiple types of seizures.
- Social history: Mom d/c all AED as mom does not believe in AED.
- Diet:
  - Initial 1296 Kcal 50% MCT KD: 21% LCT, 19% CHO, 10% protein
  - Continue adjust diet to 72% MCT, 8% LCF, 10% CHO, 10% protein
  - 15 month post diet: no seizure
  - Continue adjusting caloric intake, monitoring nutrition status, adjusting vitamins/minerals supplements according to patient's need
  - Seizure free for 3 years
  - Weaned KD to 40% MCT KD in 52 months post diet, 30% MCT KD in 55 months post diet, low CHO diet in 58 months post diet.
  - Currently, parents choose to keep pt on low CHO diet. Patient remains seizure-free.

MAD Modifications

1. Increase long-chain fat
2. Adding keto commercial formula, i.e. KetoCal® 4:1 LQ, KetoVie™
3. Adding keto powder for varieties of the baked snacks to make meals more interesting, i.e. KetoCal® powder.
4. Adding MCT oil

created by Christiana Liu

Case #4

- 9.3 yr old boy
- Dx: Chromosome 15q duplication, refractory seizures, consistent of Lennox-Gastaut syndrome, autism, global development delay.
- Meds: Epival®, Banzel®
- History: Seizures started at 8.3 yr old, severe generalized tonic-clonic, 2-3 times/night, 1-6 min each, tonic drops 5 times/day with head trauma, epileptic spasm multiple times/day.
- Social history: Single mom working full-time taking care of sick grandmother, not able to put patient on Classic or MCT ketogenic diet, start patient on Modified Atkins diet
- Slow start MAD
  - Added MCT oil at 4 months on diet, KetoCal® 4:1 LQ as a supplement and KetoCal® powder for baked snacks at 8 months on diet.
- One year on the diet:
  - Urine ketones: 8 mmol/L, occasionally at 4 mmol/L
  - >90% seizure improvement with only 10-30 sec mild tonic clonic seizures 1-2 times per night

created by Christiana Liu

Case #5

- 2.5 yr old boy
- Dx: tonic cluster seizure, brain surgery candidate, multiple admissions one month prior KD due to poor seizure control
- Diet
  - Started 975 Kcal 3:1 ratio classic KD pureed food
  - 2 months on diet: no seizures, but, difficult to feed pt. fluids
  - 5 months on diet: G-tube insertion for fluids. Due to prolonged NPO, pt received D5W continuously 8 mL/hr post-op until feeds restarted
  - Continues to be seizure-free

Ketone & Blood Glucose Stabilization During Long-Term Fasting

- >18 Hr fasting: tends to lower blood glucose and increase ketone level
- Urine ketones >16 mmol/L (160 mg/dl), BG <3 mmol/L (54 mg/dl) can cause complications
- TPN: Lipid restricted to < 3-4 g/kg body weight (BW) per day (0.13-0.17 g/kg BW/hour) to prevent "fat overload syndrome"
- Unstable ketones may contribute to increased seizures
- Low rate of continuous IV (5% Dextrose) with normal saline to meet TFI to keep patient's ketone and BG stable during long term fasting

Liu, YC, Lowe, H, Zak, M, Kobayashi J, Chan, VW, Donner EJ. Ketone stabilization during long term fasting in children on a ketogenic diet. American Epilepsy Society abstract archive. 2012.

created by Christiana Liu

Calculation Continuous IV 5% Dextrose During Long Fast

I. **Calculate the patient's daily maintenance fluid intake according to the following principles :**

For Body Weight (BW) (1-10 Kg) = 100 ml/ kg BW

For BW (11-20 Kg) =1000 mL+ 50 ml for each kg >10 kg = 1000+50(kg BW-10)

For BW >20 Kg = 1500 mL+20 ml for each kg >20 kg = 1500+20(kg BW-20)

II. Calculate daily CHO allowance = CHO content of 1/2 strength Pedialyte® to the volume of daily maintenance fluid intake:

Pedialyte®: 1000 ml contains 25 gm of CHO, 1ml = 0.025 gm CHO

Daily fluid intake from Step 1 above divided by 2 x 0.025 is the intake needed to maintain safe BG and urine ketones to prevent excessive seizures.

III. Final daily CHO intake calculations by body weight:

1. For BW (1-10 Kg): Daily CHO allowance= (100 ml x kg BW) ÷ 2 x 0.025
2. For BW (11-20 Kg): Daily CHO allowance= ({1000+50 (Kg BW-10)} ÷ 2) x 0.025
3. For BW >20 Kg: Daily CHO allowance= ({1500+20 (Kg BW-20)} ÷ 2) x 0.025

IV. D5W/hour rate= (daily CHO allowance x 100)/5 ÷ 24 hours

Liu, YC, Lowe, H, Zak, M, Kobayashi J, Chan, VW, Donner EJ. Ketone stabilization during long term fasting in children on a ketogenic diet. American Epilepsy Society abstract archive. 2012.

created by Christiana Liu

Example of the Calculations:

A 10 month old boy, weight 8 Kg, he needs to have surgery with estimated 36 hours of fasting prior, during and post surgery. This boy is on 3:1 ratio classic ketogenic diet with average urine ketone at 8 mmol/L (80 mg/dl) and blood glucose at around 4.0 mmol/L (72 mg/dl) prior surgery.

1. **Daily CHO allowance during fasting**
   = (100 x kg BW) ÷ 2 x 0.025 = (100 x 8) ÷ 2 x 0.025 = 10

2. **D5W/hour rate**
   =(daily CHO allowance during fasting ÷ 5/100) ÷24 hours = (10 ÷ 5/100) ÷24
   =8.3

3. **Post surgery: Estimated patient needs 8 ml/hr of D5 during fasting**

4. **Continue monitoring patient's BG and ketone level and readjust D5 dosage as needed**

Liu, YC, Lowe, H, Zak, M, Kobayashi J, Chan, VW, Donner EJ. Ketone stabilization during long term fasting in children on a ketogenic diet. American Epilepsy Society abstract archive. 2012.

created by Christiana Liu

Number of Patients	23
Age (yr)	0.33-16 (mean ± SD = 7.1± 3.3)
Fasting (hrs)	19-36 (mean ± SD = 22.0±3.74)
Body Weight (Kg)	7.2-41.7 (mean ± SD = 21.4±6.6)
D5W (ml/hr)	8-20 (mean ± SD = 13.7 ±2.8)
Urine Ketone (pre fasting)	6-16 mmol/L (60-160 mg/dl) (mean ± SD = 11.9 ± 2.3)
Urine Ketone (during fasting)	4-16 mmol/L (40-160 mg/dl) (mean ± SD = 10.8±2.5) (p=0.516) NS
Blood Glucose (mmol/L)	>3.5 mmol/L (63 mg/dl) (mean ± SD = 4.5±0.7 mmol/L or 81±12.6 mg/dl)
Number patient has Seizure increasing during fasting	0

Liu, YC, Lowe, H, Zak, M, Kobayashi J, Chan, VW, Donner EJ. Ketone stabilization during long term fasting in children on a ketogenic diet. American Epilepsy Society abstract archive. 2012.

Case #6

- 3.4 yr old boy
- Dx: >40 atonic-myoclonic, 2 tonic-clonic, many absence seizures/day, no inborn fat metabolic defects
- Meds: multiple AEDs including valproic acid
- Diet: PO eater, no aspiration
- Prior to diet: AED switched to Epival®, start classic KD, 1300 kcal, 3:1 ratio
- One month on diet: HS snack: 3.5:1
- Ketone = 16 mmol/L, no seizures
- 6 months on diet: starting AED weaning
- 17 months on diet: No meds, switched to MCT KD: 50% MCT, 24% LCT, 14% CHO, 12 % protein
- 27 months on diet: no meds, no seizures, patient was happier with more variety in food choices

created by Christiana Liu

Case #7

4 yr old girl with meningoencephalitis with coma in emergency

- Meds: cyclophosphamide, prednisone, clobazam, Vimpat®, Keppra®, phenobarbital
- Wt: 15 Kg
- Started NG fed
- Indirect calorimetry: 636 Kcal/day.
- Day 3 ICU admission started KD.

created by Christiana Liu

Case #7

# Day on diet	Diet	Urine ketone	
1	636 Kcal 4:1 ratio	negative	8.8 gm CHO in IV meds
2 (AM)	636 Kcal 4.5:1 ratio	negative	
2 (PM)	636 Kcal 5:1 ratio	negative	
3	480 Kcal 5.5:1 ratio	AM: 4 mmol/L PM: 8 mmol/L	
7	560 Kcal 5.5:1 ratio + 20 gm Liquigen®	8 mmol/L	
8	640 Kcal 5.5:1 ratio + 40 gm Liquigen®	8 mmol/L	
9	680 Kcal 5.5:1 ratio + 50 gm Liquigen®	8 mmol/L	
10	763 Kcal 5.5:1 ratio + 70 gm Liquigen®	8 mmol/L	
11	840 Kcal 5.5:1 ratio + 90 gm Liquigen®	8-16 mmol/L	

Case #7

# Day on diet	Diet	Urine ketone	
14	840 Kcal 5.5:1 ratio + 90 gm Liquigen®	>16 mmol/L	No juice treatment
15	880 Kcal 5.5:1 ratio + 100 gm Liquigen®	AM: 8 mmol/L PM: 16 mmol/L	
24	880 Kcal 5.5:1 ratio + 100 gm Liquigen®	16 mmol/L	No diet change **D/C from ICU**
25	880 Kcal 5.4:1 ratio + 100 gm Liquigen®	16 mmol/L	Neurology Unit, d/c **cyclophosphamide**
34	880 Kcal 5:1 ratio + 100 gm Liquigen®	16 mmol/L	Feeding assessment
35	880 Kcal 5:1 ratio + 100 gm Liquigen®	16 mmol/L	NG + oral small amount pureed meat x 1/day
40	880 Kcal 5:1 ratio + 100 gm Liquigen®	16 mmol/L	NG + oral pureed meat x 2/day

created by Christiana Liu

Case #7

# Day on diet	Diet	Urine ketone	
54	979 Kcal 5:1 ratio + 120 gm Liquigen®	16 mmol/L	NG +oral pureed meat x 2/day
57	NPO	16 mmol/L	G-tube insertion D5W: 4 ml/hr, then decreased to 3 ml/hr to 2 ml/hr to 0 ml/hr G-tube for water, formula, medications and supplements
58	979 Kcal 5:1 ratio + 120 gm Liquigen®	16 mmol/L	G-tube + oral feeds Pureed meat x 2/day
79	1101 Kcal 5:1 ratio + 135 gm Liquigen®	16 mmol/L	**D/C from hospital, transfer to Rehab**

Case #7

# Day/Month of Out-Patient	
7 Day	Lower diet ratio to 4.75:1 ratio, increase Liquigen® 144 gm to prevent seizure increase
14 Day	Increase calorie and protein intake, lower diet ratio to 4.5:1 ratio, Maintain Liquigen® Gradually adding solid food
2 Months	Lower diet ratio to 4:1 ratio
2 ½ Months	Lower diet ratio to 3.5:1 ratio to prepare switch to MCTKD, d/c prednisone
9 Months	Lower diet ratio to 1.75:1 ratio 4 meals + 47% MCT KD 3 meals, Liquigen® in all meals
21 Months	1360 Kcal, 1.75:1 ratio classic KD formula + 5 gm Liquigen® for meal one and 15 gm for meal 5 + 26% MCT KD, 3 solid foods

Case #7:

1360 Kcal, 1.75:1 ratio classic KD formula + 5 gm Liquigen® for meal one and 15 gm for meal 5 + 26% MCT KD, 3 solid foods

	Sn 1 Classic diet formula (1.75:1)	Breakfast	Lunch	Dinner	Sn2 Classic diet formula (1.75:1)
Starch		0	0	0	
Fruits/ Vegetables		0.6	0.6	0.6	
Protein		3	3	3	
Milk(skim)		0	0	0	
Fat		2.8 (14 gm)	2.8 (14 gm)	2.8 (14 gm)	
(MCT oil) Liquigen®	5 gm	25 gm	25 gm	29 gm	15 gm

created by Christiana Liu

Case #7

- Patient is able to walk, talk, in 1st grade with only finger twitching for a few seconds 5-7 times every 1 ½ week.
- CHO intake daily: 18 gm
- Urine ketone: 8-16 mmol/L
- Gradually move into MAD thru oral feeds plus Liquigen® via G-tube

Questions and THANK YOU!

Please complete our survey at
www.surveymonkey.com/r/LiuKD

Please contact your Nutricia Representative in Canada for a Certificate of Attendance or

Enter the survey code at
www.NutriciaLearningCenter.com for your CEU certificate in the US.

For question on this Webinar or Nutricia's products, please email:
NutritionServices@nutricia.com
or call:
1-800-365-7354

created by Christiana Liu