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Innovative Approaches to Managing Drug-Resistant Epilepsy in Adults: The Role of Ketogenic Diet Therapy

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Disclosures

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Elizabeth Felton, MD, PhD

- Medical Advisory Board: Glut 1 Deficiency Foundation
- Scientific Advisory Board: Epilepsy Foundation of Wisconsin
- Speaking / Consulting Honorariums
  - American Epilepsy Society
  - Nutricia North America
  - Nestle Health Science
  - Medtronic
  - Abbott

Kelly Faltersack MS, RDN, LDN, CD

- Medical Advisory Board: Glut 1 Deficiency Foundation
- Speaking / Consulting Honorariums *(Honorariums went to my employer. No personal compensation received.)*
  - American Epilepsy Society
  - Metabolic Health Summit
  - Ajinomoto Cambrooke
  - Nutricia North America

Ulrike Reichert, MS (webinar organizer)

- Employed by Nutricia North America

Rachel Powers, RD (webinar moderator)

- Employed by Nutricia North America

None pose any conflict of interest for this presentation.

The opinions reflected in this presentation are those of the speaker and independent of Nutricia North America

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Learning Objectives

- Participants in this activity will learn to:
  - Review the clinical evidence supporting the use of ketogenic diet therapy in managing drug-resistant epilepsy in the adult population
  - Learn practical strategies for implementing ketogenic diet therapy in clinical practice, including patient selection, dietary planning, monitoring, and managing potential side effects
  - Understand real-world applications of ketogenic diet therapy in managing drug-resistant epilepsy and identify best practices for optimizing patient care

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Poll Question

- Which population do you work with?
  - Pediatrics
  - Adults
  - Both, but primarily pediatrics
  - Both, but primarily adults

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Poll Question

- How many **adult** patients with epilepsy on ketogenic diet therapy do you currently support?
  - 0
  - 1-10
  - 11-20
  - 21-50
  - 51-75
  - More than 75

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Management of Adults on Ketogenic Diet Therapy

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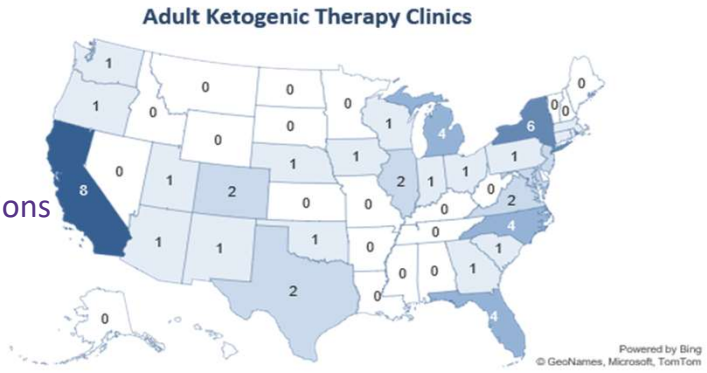
Adult Ketogenic Therapy Clinic Access

- Pediatric keto clinics
  - Most major academic medical centers
  - KDT is commonly accepted[1]
  - Guidelines have been around for longer[2]
- Adult clinics
  - International consensus recommendations first published in 2021[3]
  - Increasing patient demand
  - ➢ 22 USA states have no adult KDT center[4]
  - ➢ 17 USA states have only 1 adult KDT center[4]
  - Not as accepted,[1] despite similar efficacy



Graph created in Excel based on data from The Charlie Foundation accessed 3/17/2025[1]

1. Seaborg K, et al. J Child Neurol. 2020.
2. Kossoff EH, et al. Epilepsia Open 2018.
3. Cervenka, et. al. Neurology Clinical Practice 2021.
4. Based on data from The Charlie Foundation accessed 3/2025 https://charliefoundation.org/find-a-hospital/?region=united-states

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Efficacy in Adults with Epilepsy

~50%
of adults have
> 50% seizure reduction

- ↓ Seizure frequency
- ↓ Seizure severity
- Faster recovery after seizures
- Decrease medication or avoid the need to increase medication

Liu H, et al. Epilepsia Open. 2018.
Cervenka MC, et al. Epilepsy Behav. 2016.
Roehl K, et al. Epilepsy Behav. 2019.
Husari KS, Cervenka MC. Epilepsy Res. 2020.
Manral M, et al. Neurology. 2023.

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Advantages of Ketogenic Therapy

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- Rapid initiation
- See benefits quickly
- Broad spectrum
- Potential for other non-seizure benefits

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Potential Non-Seizure Benefits

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- Weight loss
- Improvement in other medical conditions
- Improved mood
- More energy
- Cognitive benefits
- Medication reduction
- Improved quality of life
- Able to go back to work

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Who is a Candidate?

- Intractable epilepsy
- Interested in medication reduction
- Intolerant to medication side effects
- Interested in "alternative" options
- Interested in diet for other reasons and hoping for dual benefit

For a list of absolute and relative contraindications, please see 2021 International Recommendations for the Management of Adults

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Our Workflow and Experience

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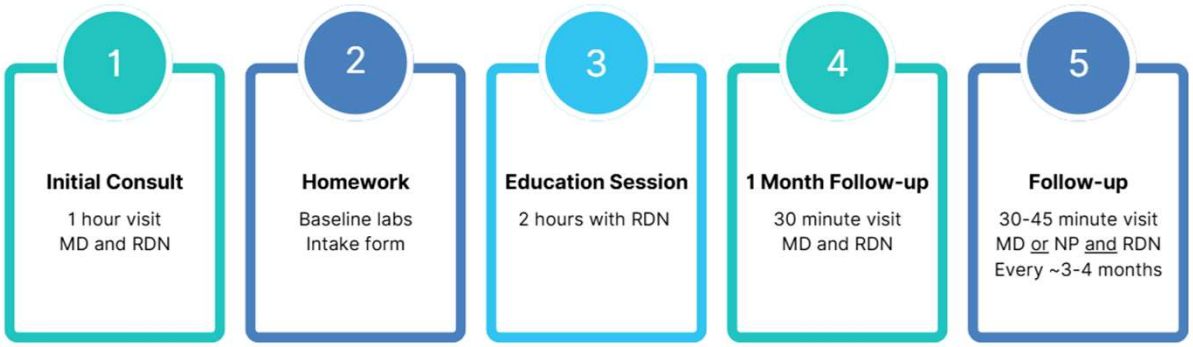
Our Clinic Workflow



Patient continues to follow with their primary neurologist (if applicable)

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Visit 1: Initial Consultation

- ☐ Take a general epilepsy history
- ☐ Screening questions focused on adults
  - ○ Coexisting medical conditions*
  - ○ Medications*
  - ○ Alcohol use
  - ○ Contraception use
  - ○ Plans for pregnancy
  - ○ History of eating disorder
  - ○ Pre-existing food restrictions (allergies, gluten-free, vegetarian, vegan, low-FODMAP, organic, artificial sweetener avoidance, etc.)
- ☐ Discuss risks vs benefits of ketogenic diet therapy*

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Coexisting Medical Conditions

Medical Condition	Pre-ketogenic diet therapy	After starting ketogenic diet therapy
Type 2 Diabetes	• Baseline HgBA1C and review of medications • Make sure managing provider is on board	• Monitor blood sugar • Improvement in glycemic control is common • May require medication adjustment
Hypertension	• If uncontrolled, need to address prior to starting ketogenic diet therapy	• Improvement in BP is common • May require medication adjustment
Obesity	• Establish weight goals • Make it clear that weight loss is not primary focus	• Weight loss is common and can be motivating! • Assess for losing weight too quickly
Hypercholesterolemia	• If very elevated at baseline, proceed with caution	• Lipids often increase initially, then trend towards baseline by 1 year • If elevated triglycerides – assess for low carnitine

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Coexisting Medications

- Adults may be on medications that require additional monitoring
- Examples (focus on non-epilepsy medications):

Medication	Concern	Recommendations
Certain blood pressure medications, such as diuretics	Electrolyte disturbance (potassium, magnesium)	Check electrolytes 1 month after starting ketogenic diet therapy
Oral hypoglycemic, insulin, metformin	Hypoglycemia	Obtain blood glucose/ketone meter and monitor blood sugar, so med adjustments can be made
Olanzapine and other drugs that can increase lipids	Elevated lipids	Check lipid panel more often
Thyroid medication	Changes in thyroid levels	PCP monitors thyroid levels and adjusts med dose if needed
Liquid or sublingual medications	Hidden carbohydrates	Convert to pill when possible Check carbohydrate content

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Side Effects – Our Experience

Most Common	Occasional	Less Common
Constipation	Other GI side effects (e.g. bloating, diarrhea)	Renal stones
Weight loss	Dizziness / lightheadedness	Acidosis
	Hyperlipidemia[1]	Weight gain
	Nutrient deficiency (e.g. vitamin D, carnitine)	Hair thinning or loss
	Change in menstrual patterns	Hypoglycemia
		Keto rash (rare)

1. Gervenka, MC et al. Nutr Neurosci. 2014

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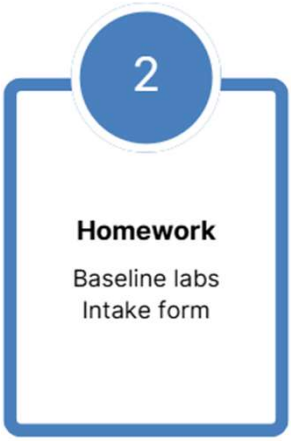
Visit 1: Initial Consultation cont.

- ☐ Patient receives keto information folder
  - ☐ Intake form (includes 3-day food record)
  - ☐ "Meet the providers" handout
  - ☐ Information about the clinic and keto FAQs
  - ☐ Calendars to record seizures / events
- ☐ Baseline labs ordered *
- ☐ Patient instructed to think about it, get labs, and return intake form



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Baseline Labs

All patients	Select patients
Complete metabolic panel, Magnesium, Phosphorus	Selenium
Complete blood count	Zinc
Lipid Panel	Copper
Vitamin D	Vitamin B12, RBC Folate, MMA, Homocysteine
Carnitine (free and total)	Urine organic acids, serum amino acids*
Urinalysis	24 Hour Urine
Urine pregnancy (in people of childbearing potential)	Hemoglobin A1C, Fasting insulin
Antiseizure medication (ASM) levels	Beta-hydroxybutyrate (BHB)
	Celiac screening: tTG-IgA, IgA

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Practical Tips

- Do not make 2 changes at once.
- Wait one month after a medication change before starting keto
- Wait 3 months after starting ketogenic therapy to make medication changes (unless there is an emergent need to make a change)
  - Set expectations up front!

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Visit 2: Dietitian Education Session

- Individualized
- Anyone involved in food prep attends
- Video visit
- "Keto starter kit"
- Supplements
  - Multivitamin with mineral (or prenatal multivitamin)
  - Calcium + D
  - *Vitamin D (as needed if deficiency is present)
  - *Levocarnitine (if carnitine deficiency is present)
  - *Potassium Citrate (if hypocitraturia on 24 hour urine)

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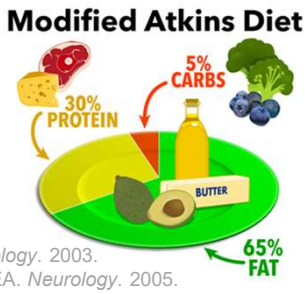
Diet Versions

The Modified Atkins Diet (MAD)

(Kossoff 2003)

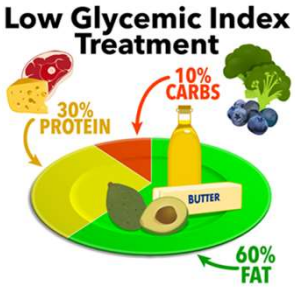
- 20 grams net carbohydrate
  - + Net = Total – Fiber
  - + Sugar alcohols are not subtracted*



Low Glycemic Index (LGIT)

(Pfeifer and Thiele 2005)

- 40-60 grams total carbohydrate
- Foods with glycemic index (GI) <50
- Meals and snacks balanced with protein and fat



Kossoff EH, et al. *Neurology*. 2003.
Pfeifer, HH and Thiele EA. *Neurology*. 2005.

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Monitoring

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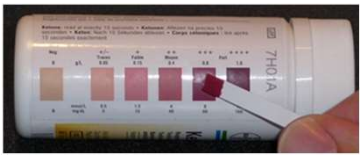
Ketone Calendar

- Ketones
  - Daily for 2 weeks
  - Then twice weekly
  - Seizure days
- Weekly weight
- Menses (if applicable)
- Seizures



January 2025	Please record the following: 1. Events – # and type of seizures, migraines, or other episodes. 2. Ketones twice weekly and on seizure/migraine days. 3. Weight weekly. 4. Medication changes. 5. If applicable, dates of menstrual cycle.					
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			Jan 1 Events: Ketones:	2 Events: Ketones:	3 Events: Ketones:	4 Events: Ketones:
5 Events: Ketones:	6 Events: Ketones:	7 Events: Ketones:	8 Events: Ketones:	9 Events: Ketones:	10 Events: Ketones:	11 Events: Ketones:
12 Events: Ketones:	13 Events: Ketones:	14 Events: Ketones:	15 Events: Ketones:	16 Events: Ketones:	17 Events: Ketones:	18 Events: Ketones:
19 Events: Ketones:	20 Events: Ketones:	21 Events: Ketones:	22 Events: Ketones:	23 Events: Ketones:	24 Events: Ketones:	25 Events: Ketones:
26 Events: Ketones:	27 Events: Ketones:	28 Events: Ketones:	29 Events: Ketones	30 Events: Ketones	31 Events: Ketones	

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Follow-Up Visits

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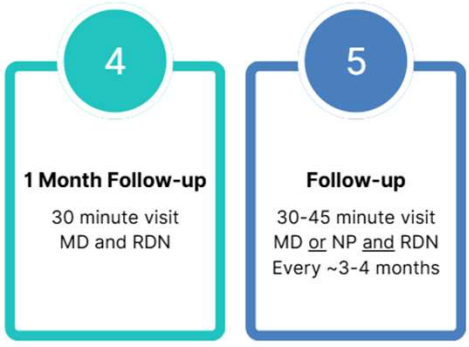
- Check vitals, including weight (important to do without shoes/coat)
- Review seizure/ketone calendars
- Monitor labs*
- Discuss side effects, barriers, impressions of efficacy and other benefits
- Ongoing education and troubleshooting
- Most important: provide encouragement!



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1 Month Labs for Select Situations

Medications	Labs
Carbamazepine Eslicarbazepine Oxcarbazepine	BMP + BHB
Diuretics Chlorothiazide, Hydrocholorothiazide, Chlorthalidone, Furosemide, Bumetanide, Torsemide	BMP, Mag, BHB
Potassium citrate	BMP

Situations	
Classic Ketogenic Tube Feeding Outpatient Initiation	BMP + BHB

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Lab Monitoring

Frequency

- 3-4 months
- Then every 6 months
- Annual for long-term patients who are stable
  - May check subset of interim labs

Other considerations

- ASM levels in patients with significant weight loss
- PCP monitor thyroid labs if taking thyroid meds

All patients	Select patients
Complete metabolic panel, Magnesium, Phosphorus	Selenium
Complete Blood Count	Zinc
Lipid Panel	Vitamin B12, RBC Folate, MMA, Homocysteine
Vitamin D	24 Hour Urine
Carnitine (free and total)	Hemoglobin A1C, Fasting insulin
BHB	Specific micronutrients
Urinalysis	
ASM levels	Other labs possible

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Antiseizure Medication (ASM) Levels

- Dose is often weight based in children, but not in adults
- Helpful to have baseline levels prior to KDT and follow-up levels after initiating
- ASM - KDT interactions are not straightforward and depend on many factors
- Possible mechanisms of interactions
  - Dehydration
  - Modified serum protein binding

Armeno and Kossoff. Epileptic Disorders. 2023.

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Special Situations and Optimizing Ketogenic Diet Therapy for Adults

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Poll Question

- When does your center initiate ketogenic diet therapy for status epilepticus?
  - Within 48 hours
  - Within 7 days
  - After a couple weeks
  - ~1 month or more
  - Only as a last-ditch effort
  - Have never used keto in the ICU

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Ketogenic Diet for Status Epilepticus

- Ketogenic diet therapy has been successfully used as an emergent, acute therapy in adults with status epilepticus
- **Tips:**
  - Protocols and orders sets are important to prevent errors
    - UW Health Clinical Practice Guideline
    - Best Practice Alert
  - No propofol in last 24 hours
  - Pharmacy assistance to minimize carbohydrates in medications
  - Hypoglycemia is only treated if less than 50 mg/dL

AVOID CARBS IN MEDS	TIPS TO MINIMIZE CARBS
1 LIQUID MEDICATIONS (SYRUPS, SUSPENSIONS, ELIXIRS)	Change to tabs
2 CHEW TABS	Change to tabs (can be crushed)
3 ELECTROLYTE PACKETS	Use IV electrolytes or tabs (if able)
4 DEXTROSE IV FLUIDS	Use normal saline, half normal saline or lactated ringers
5 DEXTROSE INJECTIONS OR INFUSIONS	Base solution of infusion should be changed to 0.9% sodium chloride or straight drug (if able)

Cervenka MC et. al. Neurology. 2017.
McDonald TJW, et al. Semin Neurol. 2020.
Kaul N, et. al. Neurol Clin Pract. 2021.
Wickstrom R, et. al. Epilepsia. 2022.

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Carnitine

and its effect on seizure control

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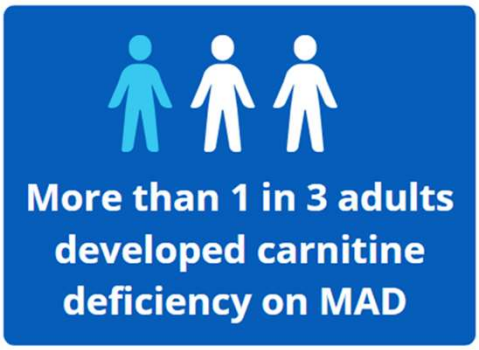
Carnitine

- Conditionally essential nutrient
- Plays an essential role in fat metabolism
- **L-Carnitine** is required to transport long chain fatty acids into the mitochondria for β-oxidation to produce energy (ATP)
- KDT may increase the risk of carnitine deficiency[1,2]
- 38% of adults developed carnitine deficiency on MAD[3]
  - Most (55%) within 3-9 months[3]
  - Can occur at any time[3]



1. Neal EG, et al. Epilepsy Res. 2012.
2. Kossoff EH, et al. Epilepsia Open. 2018.
3. Chu, DY, et al. Front Nutr. 2024.

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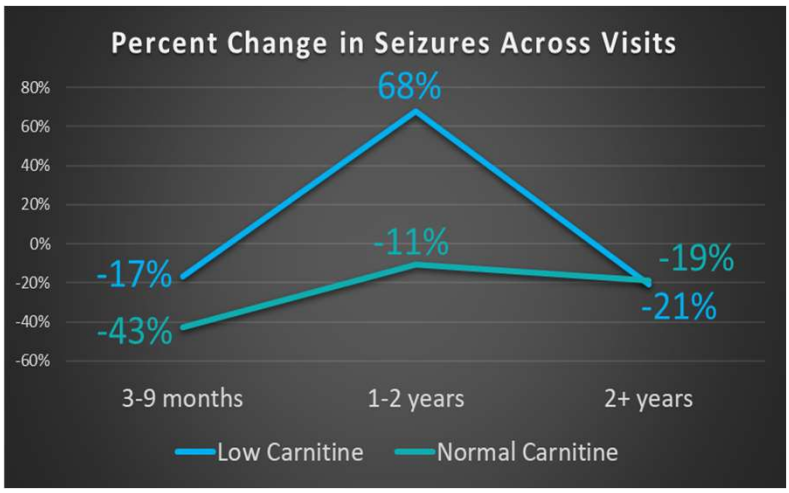
How Carnitine Deficiency Impacts Seizures



Adapted from Chu, DY, et al. Front Nutr. 2024.

- Normal carnitine group had ↓ seizures at each timepoint.[1]
- At 1-2 years, the low carnitine group had a **significant seizure increase** (p 0.0372) [1]

1. Chu, DY, et al. Front Nutr. 2024.

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Practical Tips for Carnitine Supplementation

- Best absorbed and tolerated in divided doses with food
- Can cause GI side effects
- Start with 1 tab per day and work up to goal dose to improve tolerability
- Must be kept in blister packaging or tabs dissolve
  - May not fit in pill box

Photo by Marek Studzinski on Unsplash

Carnitine Food Sources

Food	Serving	L-Carnitine (mg)
Lamb	3.5 oz	190
Beef steak	3 oz.	81
Ground beef	3 oz.	80
Pork	3 oz.	24
Canadian bacon	3 oz.	20
Milk, whole	8 oz (1 cup)	8
Fish (cod)	3 oz.	5
Chicken breast	3 oz.	3
Cheese, cheddar	2 oz.	2
Avocado	1 medium	2
Asparagus	½ cup (6 spears)	0.2

Table adapted from the references below
https://ods.od.nih.gov/factsheets/Carnitine-HealthProfessional/
https://lpi.oregonstate.edu/mic/dietary-factors/L-carnitine
Kulczyński B, et. al. Antioxidants. 2019.

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Medium Chain Triglycerides (MCT) Oil

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Medium Chain Triglycerides (MCTs)

- Rapidly absorbed and converted to ketones
- Boosts ketosis
- Does not require carnitine
- Studies have shown an **anti-seizure effect** from C10 MCT
- Choose MCT oil with both **C8** (Caprylic Acid or Octanoic acid) **and C10** (Capric Acid or Decanoic acid) oil.
- Can be expensive
- GI side effects may be hard to tolerate
  - Useful tool to manage constipation

Shah ND, Limketkai BN. *Practical Gastroenterology*. 2017.
Chang P, et al. Brain. 2016.
Schoeler NE, et al. Brain Commun. 2021.

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Practical Tips for MCT

- Better tolerated if increased slowly and given in divided doses
- Can be mixed into food or drinks
- Do not use for heat cooking
- Should not be sole source of fat
  - Essential fatty acids must be included
- MCT oil pills? Not recommended
  - Pill burden is too high
  - 5 MCT capsules = 1 tsp.
  - 15 capsules = 1 tsp. per meal
- Wait to introduce MCT

Example MCT Oil Titration

Day	MCT Amount
1	1 tsp. (5 mL) 3 x daily
4	2 tsp. (10 mL) 3 x daily
7	1 Tbsp. (15 mL) 3xdaily

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MCT Oil – Favorite Strategies

- Incorporate with breakfast
- Dose with meals like a medication
- Pair MCT and LCT for evening snack

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Summary

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Summary

- Ketogenic therapy is safe and effective for adults with epilepsy.
- Ketogenic therapy should be presented as an option.
- Expanded access is needed for more widespread implementation in adults.
- Medical supervision from a specialized team of experts is critical because there are several important considerations and strategies that may impact efficacy.

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References

1. Seaborg K, et al, J Child Neurol. 2020
2. Seaborg K, et al. J Pediatric Epilepsy. 2020.
3. The Charlie Foundation accessed 3/2025. https://charliefoundation.org/find-a-hospital/?region=united-states
4. Cervenka MC, et. al. Neurology Clinical Practice 2021.
5. Liu H, et al. Epilepsia Open. 2018.
6. Cervenka MC, et al. Epilepsy Behav. 2016.
7. Roehl K, et al. Epilepsy Behav. 2019.
8. Husari KS, Cervenka MC. Epilepsy Res. 2020.
9. Manral M, et al. Neurology. 2023.
10. Cervenka MC, et al. Nutr Neurosci. 2014.
11. Kossoff EH, et al. *Neurology*. 2003.
12. Pfeifer, HH and Thiele EA. *Neurology*. 2005.
15. Armeno and Kossoff. Epileptic Disorders. 2023.
16. Neal EG, et al. Epilepsy Res. 2012.
17. Kossoff EH, et al. Epilepsia Open. 2018.
18. Cervenka MC, et al. Neurology: Clinical Practice. 2020.
19. Kulczyński B, et. al. Antioxidants. 2019.
20. Chu, DY, et al. Front Nutr. 2024.
21. Shah ND, Limketkai BN. *Practical Gastroenterology*. 2017.
22. Chang P, et al. Brain. 2016.
23. Schoeler NE, et al. Brain Commun. 2021.
24. Cervenka MC et. al. Neurology. 2017.
25. McDonald TJW, et al. Semin Neurol. 2020.
26. Kaul N, et. al. Neurol Clin Pract. 2021.
27. Wickstrom R, et. al. Epilepsia. 2022.

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Thank you!
Questions?

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