KETOGENIC DIET: INPATIENT MANAGEMENT - CHW

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

- The Ketogenic Diet (KD) is a medically supervised high-fat, adequate protein and low carbohydrate diet that is used to treat refractory epilepsy and a metabolic condition called Glucose transporter 1 (GLUT 1) deficiency syndrome.
- The majority of patients commence the KD as an outpatient, however in certain circumstances the KD is initiated in the hospital.
- There are different KD types. The Children's Hospital at Westmead (CHW) most commonly uses the Modified Atkins Diet (MAD) version of the KD.
- Commencing a KD requires collaboration between members of the KD team (treating neurologist, dietitian, neurology clinical nurse consultant, pharmacist, ward nursing and neurology team parents and patients.
- Maintaining a KD can be difficult. Parent and patient education is essential in achieving optimal compliance and positive benefits /effects. Education includes assisting the family to understand the principles of the diet, preparation/meal planning, providing the family with resources and follow-up appointments to check progress.

Approved by:	SCHN Policy, Procedure and Guideline Committee	
Date Effective:	1st July 2021	**Review Period**: 3 years
Team Leader:	Ketogenic Dietitian	**Area/Dept**: Nutrition & Dietetics. Neurology

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CHANGE SUMMARY

- New protocol for highlighting that a patient is on the KD via allergy system on Powerchart
- Addition of 'Management of Fasting Periods and Surgery' and 'Management of Intercurrent Illness' sections.
- Prescription of hypoglycemic treatment for infants < 12 months and children > 12 months.

READ ACKNOWLEDGEMENT

- All CHW clinical staff responsible for decision-making regarding the commencement and management of the KD should read acknowledge they understand the contents of this document. This includes:
  - Nursing staff (in particular staff on Commercial Travellers ward)
  - Medical staff (in particular Neurology Registrars, Fellows and Consultants)
  - Dietetic staff
  - Pharmacists

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Introduction

The KD is well recognised internationally and may be a successful treatment for eligible patients with refractory epilepsy or GLUT-1 deficiency syndrome[1, 2]. Up to 70% of children with epilepsy could have their seizures controlled with anti-epileptic drugs (AEDs)[3]. For some children who continue to have seizures, the retrospective and prospective studies[1] have shown a greater than 50% reduction in seizures in children with refractory epilepsy placed on the KD, and some became seizure free after only 3 months. The exact mechanism of action still remains unclear, though it is suggested that the high fat and low carbohydrate content of the KD mimics the body's biochemical response to starvation, relying on fat rather than carbohydrates for energy[4]. The production of ketone bodies may also have epigenetic and metabolomic effects, resulting in amelioration of seizure activity.[5-6]

Definition

The KD was first used in 1921 when it was noted that seizures reduced in epilepsy patients who were fasted.[4,7] The KD aims to simulate the fasting metabolism, by shifting the body's energy source from carbohydrate and glucose, to fats derived from ketone bodies.

The KD is very high in fat (such as butter, margarine, cream and oil) and low in carbohydrate,[7] with adequate amounts of protein. Regular monitoring helps to ensure there is the right balance of dietary fat and carbohydrate to maintain ketosis.

Ketones are produced by the body from the breakdown of fats[8,9,10]. Ketones are used by the brain and muscles as a source of energy instead of glucose from carbohydrates[8,9,10]. Ketones can be measured in the urine and blood, and these levels can help us monitor that the diet is producing ketones[7,8,10]. Although the diet is high in fat, total energy intake is balanced and monitored to allow for normal weight and growth[8,9]. A child on the KD should not gain more weight than expected.

Types of Ketogenic Diets

- Modified Atkins Diet (MAD)
- Classical Ketogenic Diet
- Medium Chain Triglyceride Diet (MCT)
- Modified MCT diet
- Low Glycaemic Index (GI) treatment for Epilepsy (LGIT)

Note: The neurology team at The Children's Hospital Westmead usually recommends the Modified Atkins Diet (MAD) for children who eat and drink orally, due to ability to maintain adequate ketosis and increased compliance on this diet.

Indications for the Ketogenic Diet

Eligibility for the KD is mainly based on the child's underlying disorder[10,11] and feasibility of the family to manage the diet at home. Collaboration with the family is essential to determine the child's normal dietary/food patterns, usual meal planning and what is age-appropriate. This information will help determine the most appropriate type of KD and compliance factors can also be anticipated and addressed.

Ketogenic Diet in the Hospital

The majority of patients commence the KD as an outpatient, however in certain circumstances the KD may be initiated in the hospital. These include if the infant is < 12 months of age, or if there are concerns that the family cannot commence the diet at home without medical supervision. Parent and patient education is essential to optimise compliance and to help achieve optimal seizure control. This includes providing the family with KD-specific information such as administration of medications (ideally sugar-free or minimal carbohydrate content formulations), how to test urine for ketones and interpret results, and meal planning based on the child's nutritional requirements.

If a child is admitted to CHW and is on a KD, the treating Neurologist, Neurology CNC, Ketogenic Dietitian must be contacted on admission. Advice will need to be sought from the treating Neurologist before prescribing new medications or IV fluids, as they may contain glucose/ or sugar alcohols, and subsequently influence the effectiveness of the KD.

Where possible, medications must be sucrose and sorbitol-free. This typically involves changing pre-existing liquid/syrup medications to tablet form, to reduce excess carbohydrate.

Prior to changing, liaise with Pharmacy to assist with the prescribing of alternative formulations. This is because some AEDs may be more difficult to modify due to bioavailability and/or solubility issues and this may require a dose adjustment by prescribers.

In instances where this is not possible, please contact the Ketogenic Dietitian to adjust the carbohydrate content in feeds or meals as needed.

Although sorbitol can be used by the body as carbohydrate, this may be preferable to sucrose-containing formulations, if there are no suitable tablet forms available.

Suitable carbohydrate-free laxatives are Movicol and Osmolax. Glycerol suppositories are suitable for use in KD.

The KD will be listed as an 'Allergy' on Powerchart when the diet is initiated, as a way of alerting other medical teams that the patient is on a diet that restricts carbohydrate. This will be removed if/when the patient discontinues the diet.

"Patient on ketogenic diet: sugar/carbohydrate containing medications (i.e. syrups and glucose containing fluids) may be contraindicated unless treating hypoglycaemia, please discuss with doctor/dietician/pharmacy."

Commencement of Ketogenic Diet Flowchart

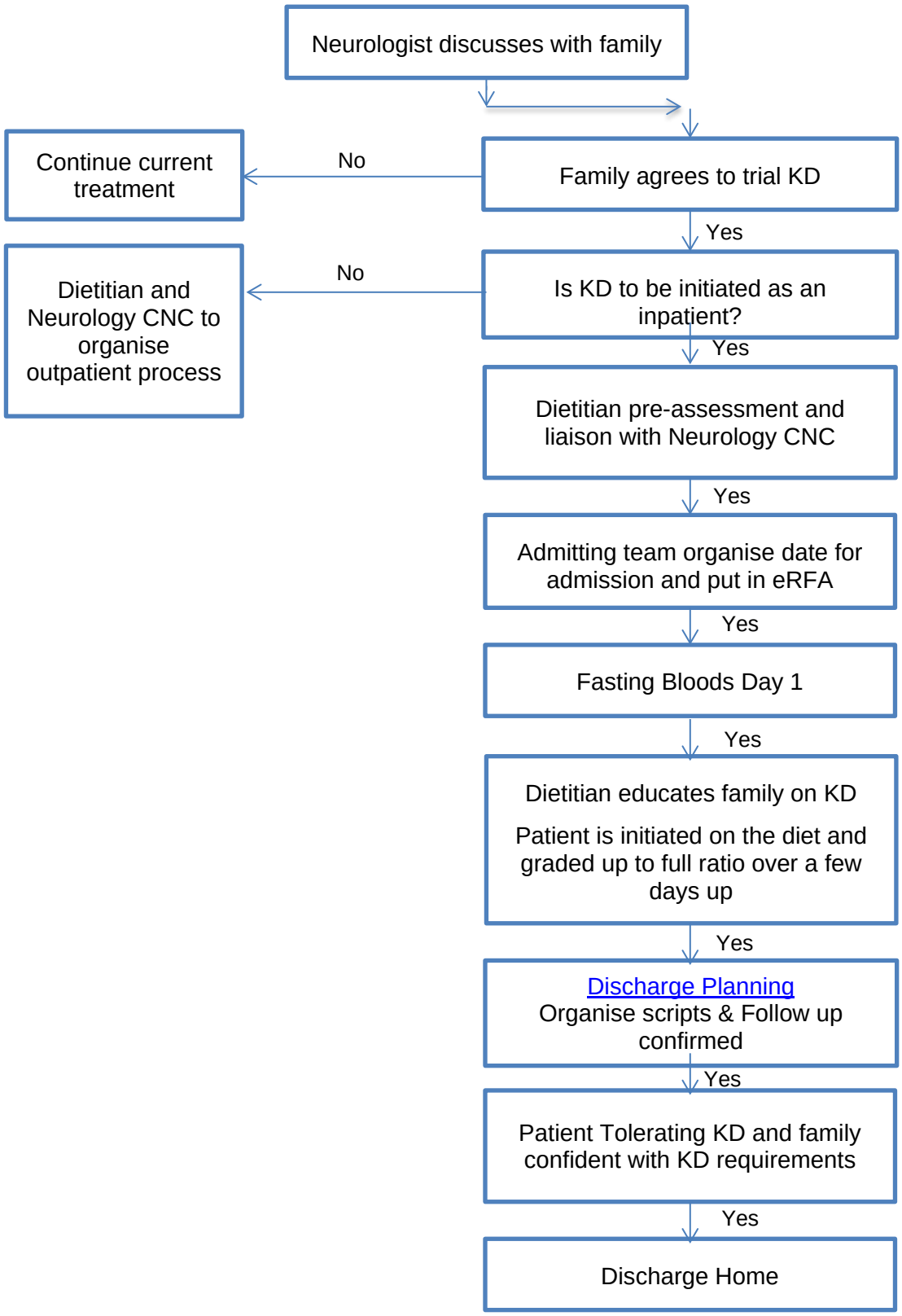

Figure 1: Commencement of Ketogenic Diet Flowchart

Monitoring:

Blood Glucose Level (BGL)

- Low BGLs may occur during the initiation stages of the KD or during periods of fasting
- Unless clinically indicated, BGLs are usually monitored 1 hour post main meals until established on KD or as directed by the Ketogenic Dietitian/neurology team
- In infants < 12 months or low body weight, there is an increased risk of low blood sugar levels, therefore 4 hourly BGLs may be used for monitoring whilst initiating the KD
- Staff should be familiar with clinical signs of hypoglycaemia, however episodes may be asymptomatic, particularly in younger children.
- Symptoms of hypoglycaemia include irritability, sweating, dizziness, shakiness, hunger or palpitations (rapid pulse) [5]

Ketone levels

- Test urine with Bayer Keto-Diastix, twice per day (morning/evening) **OR** if testing blood ketones twice per day.
- Testing blood ketones and frequency needs to be confirmed with treating neurologist and setting the expectation for monitoring once discharged home.
- Nursing staff are to record result as mmol/L on eMR Fluid Balance Chart (urinary range 0-16mmol/L or blood range 3.5-5.5mmol/L)[5]
- If 2 x consecutive readings of: urinary ketones at 16mmol/L or blood ketones > 6mmol/L **AND** symptomatic[5] (food refusal, nausea, rapid shallow breathing, facial flushing, vomiting, excessive tiredness or lethargy and increased heart rate),
- Contact Ketogenic Dietitian and Medical Officer and treat with:
    - Children < 12 months:
        - 1 mL/kg of 50% w/v Carb Plus solution Provided by formula room. Recipe is 50 g of Carb Plus made up to 100 mL of water.
        - Contains 47 g of carbohydrate in 100 mL solution[12.]
        - If this is a new admission required on weekends, please contact on-call dietitian. If after hours, please contact Medical Officer for appropriate medical treatment.
    - Children > 12 months:
        - 30mL of ward stock juice orally or via feeding tube. Contains 2g carbohydrate.
- Ensure patient is adequately hydrated as dehydration can contribute to high ketones.

Management of Fasting Periods and Surgery

- If a child is for fasting ketogenic bloods, water is allowed prior to blood test.
- If a patient is for IV fluid maintenance, use sodium chloride 0.9% or equivalent as this does not contain glucose.
- After a procedure or surgery, the KD should be reintroduced as soon as possible.
- For extended periods of fasting e.g. > 12-24 hours, 4 hrly BGLs are clinically indicated to monitor for hypoglycaemia.
- Children on the KD can safely undergo general anaesthesia (GA) and surgical procedures, however they can be at risk for developing metabolic acidosis during GA, particularly during prolonged surgical procedures.[14]
- If procedures are long (> 3 hours), it is recommended that serum pH or bicarbonate levels are used to monitor for acidosis.[14]
- This may be particularly relevant for children on topimirate as adjunctive antiepileptic therapy, as it inhibits carbonic anhydrase and may result in metabolic acidosis from decreased serum bicarbonate.[15]
- If the child develops acidosis perioperatively, intravenous bicarbonate should be used as clinically indicated.[14]

Management of Intercurrent Illness

- During periods of illness, ketone levels may be reduced due to infection / the inflammatory response.
- If a child has vomiting or diarrhoea, the Ketogenic Dietitian should be contacted, to consider reduction of feed ratios (if on Classical Ketogenic feeds) or modification of menu items (if on Modified Atkins Diet)
- It is important to maintain adequate fluid intake via KD-suitable fluids e.g. Ketocal, water or sugar-free cordial, as dehydration can cause high ketones.
- If the child has ongoing losses from vomiting and diarrhoea, half-strength Hydralyte® (1 tablet in 100 mL water = 1.6g glucose) or half-strength Gastrolyte® (1/2 sachet in 100mL of water = 1.8 g glucose100 mL) may be used to maintain hydration and blood sugar levels.
- Please ensure volume of oral rehydration solution is documented clearly on the fluid balance chart.

Nursing Responsibilities

- Testing urine for ketones and documenting level in mmol/L on eMR Fluid Balance Chart.
- If concerns regarding accuracy of urinary ketones or difficulty in obtaining sample, blood ketones can be used to cross-check during admission
- Ongoing education to carers with the aim to discharge carers with competence to measure and interpret urinary and/or blood ketones.
- Record accurate intake of KD on Fluid Balance Chart (including food that is not eaten). Inform Ketogenic Dietitian of concerns regarding ketone levels, BGL, tolerance of feeds/diet or poor compliance of diet.
- Liaise with medical officer and Ketogenic Dietitian of any side effects of the KD diet (abdominal pain, diarrhoea, lethargy, nausea and vomiting).
- If the patient has a history of hypoglycaemia on the diet, BGLs should be monitored with treatment as per flow chart below.

Blood Glucose Monitoring

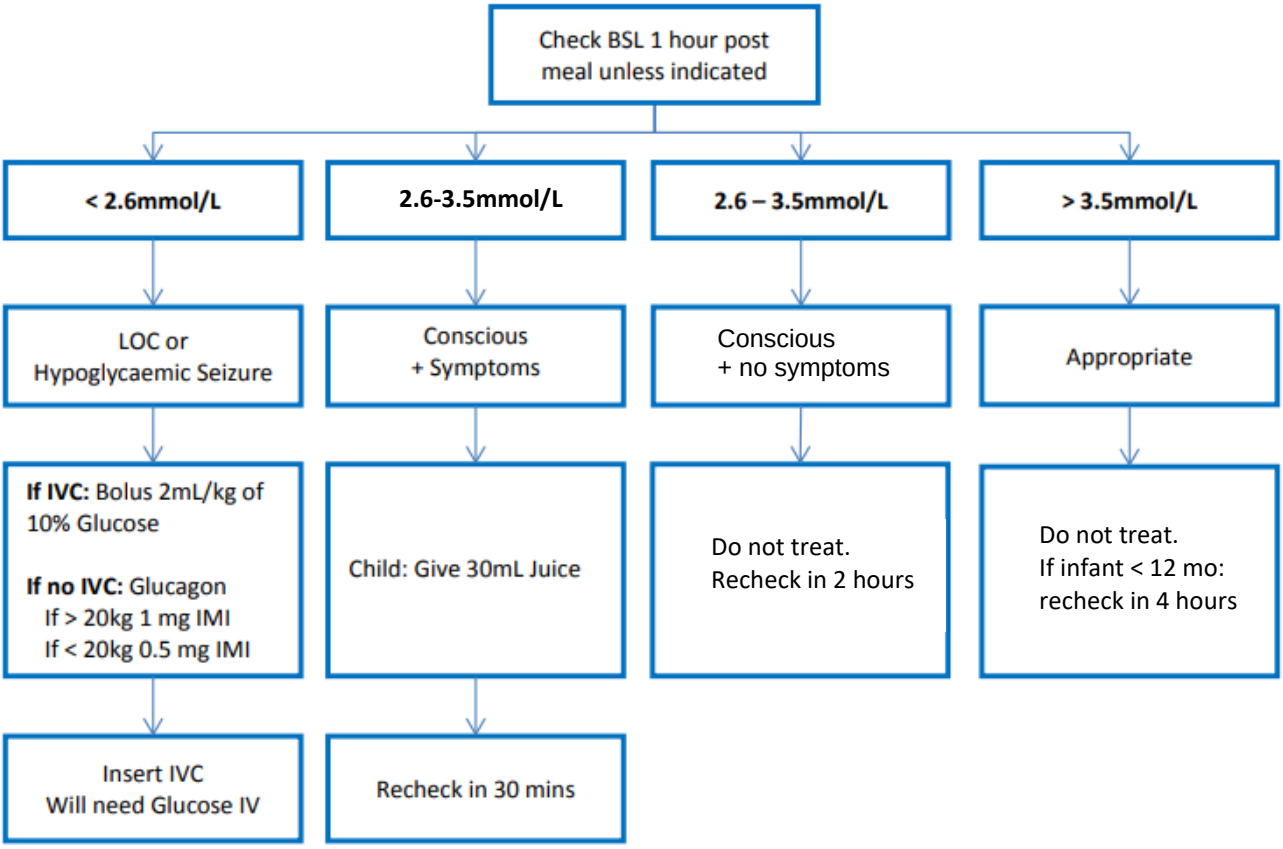

Figure 2: Flow chart of hypoglycaemic management

Ketone monitoring

Once the patient is established onto usual ketogenic diet or feeds, monitoring can be conducted via urinary or blood ketones, with treatment as per flow chart below.

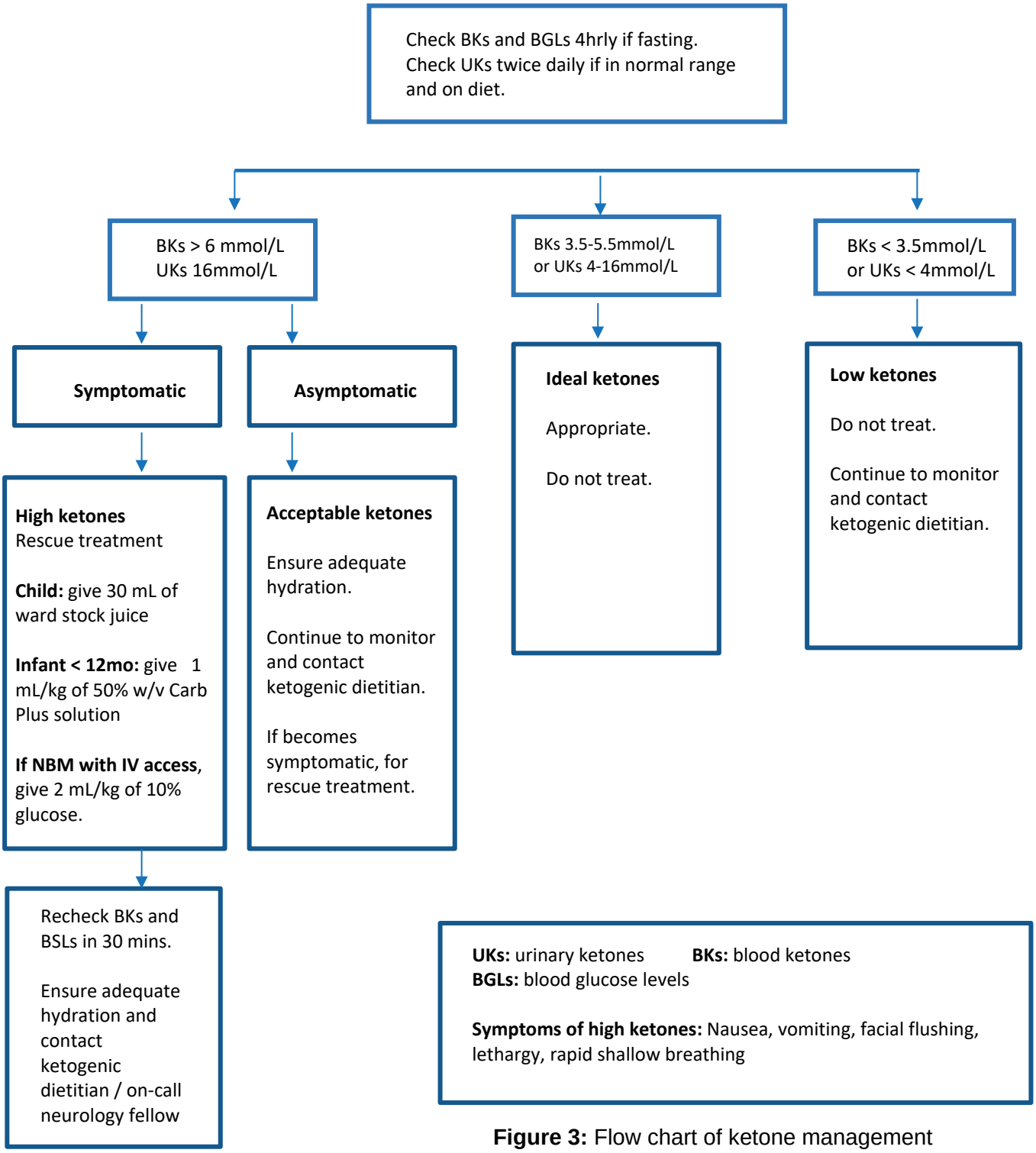

Figure 3: Flow chart of ketone management

Dietitian Responsibilities

- Conduct full nutritional assessment including suitability of patient and family to commence KD.
- Review pre-KD bloods, consult with treating neurology team.
- Liaise with nursing staff/neurology team regarding progress of the KD, ketogenic bloods, medical scripts before discharge.
- Provide education to parents/carers, including diet troubleshooting, signs and symptoms of hypoglycaemia, excess ketosis and treatment
- Monitors patients' ketone levels, blood sugar levels, and side effects (abdominal pain, vomiting, lethargy, nausea or constipation) and adapts diet to fine-tune ketosis.
- If patient is on Modified Atkins diet (MAD), ensure correct menu is sent to patient for meal selection.
- Monitor compliance with the diet.
- Liaise with Clinical Nurse Consultants (CNCs) to document KD as Allergy on Powerchart

(See Clinical Nutrition Guidelines for Ketogenic Diets – Department of Nutrition and Dietetics)

Medical Responsibilities

- Order fasting KD pre-diet blood tests (pre-set on Powerchart)
- Re-chart medication if current medications are non-compliant with the diet
- Liaise with the multidisciplinary team and patient's family daily to assess clinical progress and preparing the family for discharge
- Liaise with dietitian and pharmacists for scripts prior to patient discharge
- Ensure KD is listed as an 'Allergy' on Powerchart

Pharmacist Responsibilities

- Ensure medication history is documented to include the appropriate formulations for patient whilst on KD, including instructions for preparing doses, for example, crush and dispersing tablets.
- Ensure inpatient medications are verified with appropriate formulation assigned for patient on KD
- Liaise with treating neurology team and Ketogenic Dietitian to recommend any changes or alternative preparations required to comply with KD requirements

Discharge Planning

- Treating neurology team to arrange prescriptions for KD formulae, glucose/ketone diagnostic strips, and multivitamins. Certain KD formulas must be ordered as an Authority script (see appendix 1).
- CNCs to assist with discharge planning and routine follow up.
- Parents/carers provided with relevant team members' contact details.
- Ketogenic Dietitian and multidisciplinary team to ensure parents/carers are confident in maintaining KD in the home setting.
- Follow up appointments to be confirmed with Ketogenic Dietitian and the treating neurology team.

KD Resources

- Ketogenic Diet Parent Information Sheet
- The Charlie Foundation: https://www.charliefoundation.org/
- Matthews Friends: http://www.matthewsfriends.org/

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Appendix 1 – Ketogenic Bloods

Fasting ketogenic bloods should be taken at baseline, 3 months and 12 months on diet (if nil concerns at 3 months), with annual bloods for the duration of the diet. Urine samples should also be taken to due to risk of nephrocalcinosis and kidney stones on KD.

- ☑ Albumin level
- ☑ Calcium, magnesium and phosphate levels
- ☑ Electrolytes, urea and creatinine
- ☑ Full blood count
- ☑ Iron and ferritin
- ☑ Folate
- ☑ Liver function tests
- ☑ Vitamin B12
- ☑ Vitamin D 25 Hydroxy level
- ☑ Selenium level
- ☑ Zinc level
- ☑ CRP level

- ☑ Carnitine profiles
- ☑ Glucose level
- ☑ Beta-hydroxybutyrate (BHB) level
- ☑ Cholesterol and triglyceride levels

Urine

- ☑ Calcium : creatinine ratio
- ☑ Citrate: creatinine ratio

Appendix 2 – Prescribing for the Ketogenic Diet

When commencing the KD, the following PBS scripts need to be provided prior to discharge by the treating neurology team.

Classical KD script requirements: nil authority scripts

- KetoCal 4:1 OR KetoCal 3:1, 300g can x 24 tins x 5 repeats (Nutricia)
- Keto-Diastix - Glucose and ketone indicator urine 2 x 50g diagnostic strips x 2 repeats

MAD script requirements: nil authority scripts

Script 1: Nutricia

- Vanilla KetoCal 4:1, 300g can x 24 tins x 5 repeats
- Unflavoured KetoCal 4:1, 300g can x 24 tins x 5 repeats
- KetoCal 4:1 LQ, 200ml tetra-packs x 32 x 5 repeats

Script 2: Vitaflo

- Fruiti Vits (Vitaflo) 6g x 30 x 5 repeats
- Keyo 100g tubs x 48 x 3 x 5 repeats

Script 3: local pharmacy

- Keto-Diastix - Glucose and ketone indicator urine 2 x 50g diagnostic strips x 2 repeats