



An introductory guide for the practical implementation
of the **ketogenic diet (KD)** for the dietary management
of epilepsy and neurometabolic disease



VitaFlo in Association
With You

Supporting education in the
dietary management of rare diseases



Introduction

Purpose

This practical guide is for use as an aid to implementation of the ketogenic diet (KD) for the dietary management of children aged 1 year or over and adults with epilepsy or an inherited neurometabolic disease, i.e. Glut-1 deficiency syndrome (Glut-1 DS) or pyruvate dehydrogenase deficiency (PDHD). The KD can also be used in the dietary management of other conditions including cancer and neurological diseases, however, this guide will focus on dietary management of epilepsy, Glut-1 DS or PDHD only.

Introducing and adjusting the KD is dependent on the individual patient. Practical examples are given in this guide. However, it is the responsibility of the managing health care professional to use clinical judgement to introduce and adjust the KD in the most appropriate way for individual patients, and it may not always be appropriate to follow the examples in this practical guide.

Intended users

This practical guide is:

- for use by **health care professionals** working with children aged 1 year or over and adults diagnosed with epilepsy, Glut-1 DS or PDHD.
- not for use by parents/caregivers of patients with epilepsy, Glut-1 DS or PDHD, or patients themselves.
- for **general information** only and must not be used as a substitute for professional medical advice.

Important note

For infants i.e., those under 12 months of age, further guidance from specialist resources should be sought.

Product information

Any product information contained in this practical guide, although accurate at the time of publication, is subject to change. For the most up-to-date detail, including allergen content, refer to product labels and/or www.vitafloweb.com.



Disclaimer

The information contained in the practical guide is for general information purposes only and does not constitute medical advice. The practical guide is not a substitute for medical care provided by a licensed and qualified healthcare professional and Vitaflo® (International) Ltd does not accept any responsibility for any loss arising from reliance on information contained in this practical guide.

This practical guide should be read in conjunction with local, national and international guidelines and best practice for the dietary management of epilepsy, Glut-1 DS or PDHD. Information contained within the guide is based on the most recent scientific evidence available on the use of the KD in the dietary management of epilepsy, Glut-1 DS and PDHD at the time of publication.

This practical guide does not establish or specify particular standards of medical care for the treatment of any conditions referred to in this practical guide.

Vitaflo (International) Ltd does not recommend or endorse any specific tests, procedures, opinions, clinicians or other information that may be included or referenced in this practical guide.

It is the responsibility of the Multi-Disciplinary clinical Team (MDT), i.e. a dedicated **keto-team***, to ensure patients managed on the KD are suitable to undergo this form of dietary therapy and they undertake and implement all the assessments, procedures, investigations and monitoring required in accordance with locally agreed procedures specific to the intervention.

* N.B. The term '**keto-team**' is a generic description for those healthcare professionals (for example, dietitians, clinicians, nurses) involved in the implementation, follow-up and care of patients on a KD.



Contents

1.0	What is a KD?	3
2.0	The KD in more detail	5
2.1	Use of the KD	
2.2	Foods used in the KD	
3.0	Comparison of the 5 versions of the KD, and considerations	9
4.0	Pre-KD assessments and clinical outcomes	13
4.1	Clinical and dietetic	
4.2	Anthropometric	
4.3	Dietary	
4.4	Choosing a version of the KD	
5.0	Training for the KD	18
6.0	Making dietary changes before starting the KD	19
7.0	References	20



Abbreviations

AED	Anti-epileptic drug
CKD	Classical ketogenic diet
DRE	Drug-resistant epilepsy
KD	Ketogenic diet
LCT	Long chain triglyceride
LGIT	Low glycaemic index treatment
MAD	Modified Atkins diet
MCT	Medium chain triglyceride
MCTKD	Medium chain triglyceride ketogenic diet
Modified KD's	All modified KD's, i.e. MAD , LGIT and MKD (umbrella term)
MKD	Modified ketogenic diet



Collaborator

Elizabeth Neal MSc PhD RD, Specialist Ketogenic Dietitian, Matthew's Friends Clinics and Honorary Research Associate, UCL- Institute of Child Health, London, UK.

1.0 What is a KD?

Figure 1 represents the relative proportions of energy from macronutrients typically consumed in the human diet. Intake of a high proportion of carbohydrate in comparison to fat and protein combined results in the production and utilisation of glucose as the major source of fuel for the body when sufficient food is eaten.

In comparison, macronutrient distribution and content is manipulated in the KD so energy from fat significantly predominates over that from carbohydrate and protein combined (**Figure 2**).

The very high fat content of the KD produces ketones from dietary fatty acids which are used as the main energy source instead of glucose from carbohydrates i.e. the KD is designed to be 'keto-genic' – ketone generating. Provided carbohydrate is restricted, adequate protein included and sufficient fat consumed to meet individual energy requirements, glucose release from muscle and organ breakdown is minimised, in favour of ketone production^{1,2}.

Figure 1.
Typical human diet

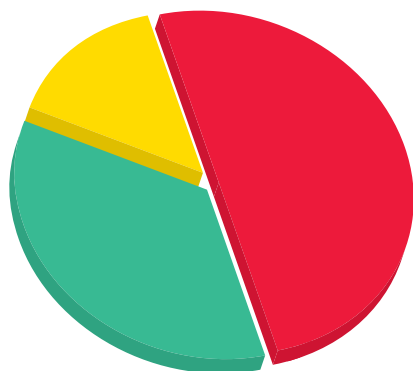
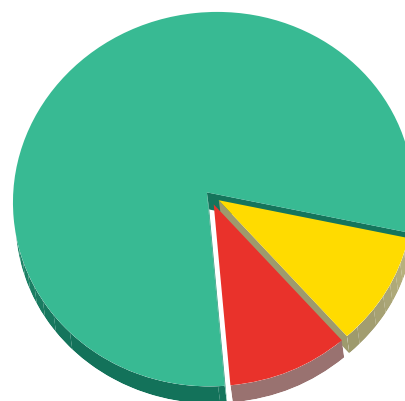





Figure 2.
Ketogenic Diet



Fat 
Protein 
Carbohydrate 

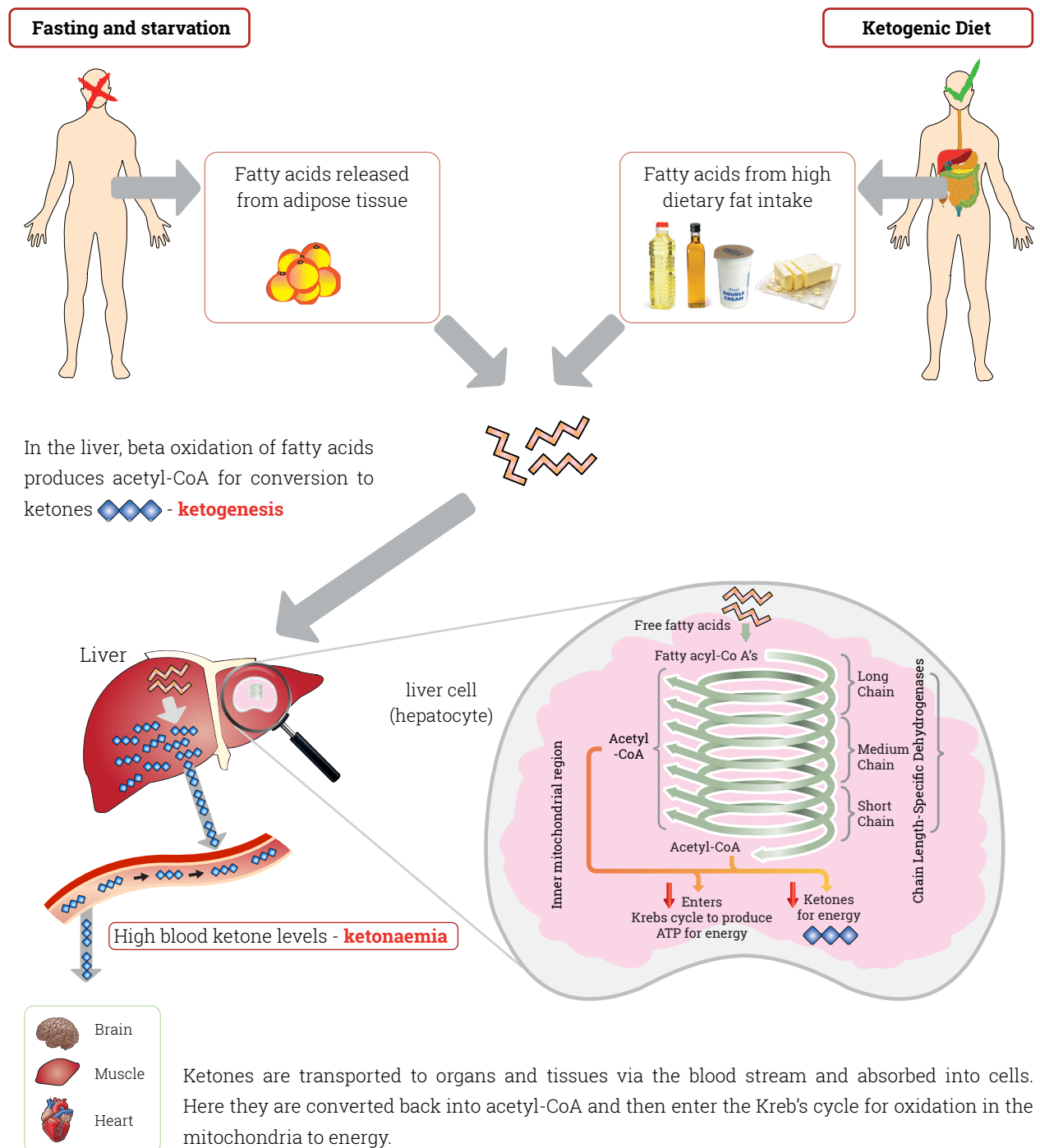
History and development of the KD²⁻⁶

The response of the body to fasting and starvation is a 'metabolic shift' from the production and usage of glucose predominantly from dietary carbohydrates to ketones generated from fat stored in adipose tissue (**Figure 3**).

Following observations dating back to the 5th century BC by Hippocrates that fasting led to seizure reduction, the KD was designed in the 1920's to replicate this metabolic process.

The KD proved efficacious in the management of epilepsy in children and adults. It was widely used prior to the increased availability of anti-epileptic drugs (AEDs) in the late 1930's. Then, seen as complex in comparison, its use declined until the early 1990's when interest in the application of the KD began to re-emerge as an adjunct or alternative to medication⁶.

Figure 3



N.B. the degree of ketosis achieved via the KD is an individual response to an individual dietary regime. It does not always correlate with successful seizure control or other improvements in well being - both high and low ketone levels can produce equally good results^{7,8}.

2.0 The KD in more detail

2.1 Use of the KD

The KD has proven efficacy in the dietary management of:

- **Drug resistant epilepsy (DRE):** At least one-third of all patients with epilepsy fail to respond adequately to AEDs, and in addition to lack of seizure reduction and control, side effects from medication can contribute towards a poor quality of life^{9,10}.

Studies on the use of the KD in children and adults with DRE show the proportion achieving 50% or greater reduction in seizure frequency ranges from 35- 56%, and that 0-15% attain seizure freedom¹¹.

The exact mechanism (or mechanisms) by which the KD can be successful in the dietary management of DRE has yet to be fully elucidated. However, the consumption of a high proportion of daily energy requirements from fat combined with a low intake of carbohydrate appears crucial. It is likely the benefits of the KD, which in addition to control of epileptic symptoms may include, for example, improvements in cognition, sleep, developmental progress and well-being, are due to more than ketosis alone^{1,2,7,8}.

- **Inherited neurometabolic disease e.g. Glut-1 DS:** A genetic defect in primary glucose transport via the Glut-1 transporter enzyme across the blood brain barrier reduces its availability as a fuel source within the brain, resulting in seizures, complex movement disorders and global developmental delay. A range of phenotypes from mild to severe are exhibited and the condition is diagnosed from infancy through to adulthood¹².

Glut-1 DS was first described in 1991 by De Vivo and colleagues¹³. This coincided with renewed interest in the KD and its application. The KD is now central to the effective management of Glut-1 DS as the ketones generated are able to enter the brain directly to provide an alternative and efficient energy supply. This promotes brain growth and development in infancy and early childhood, and facilitates more normal neuronal function and symptom control¹⁴.

The KD now and in the future

Renewed interest and use of the KD, together with associated clinical and scientific research, has been gathering momentum up to the present day and looks set to continue into the future. It has further established the efficacy of the KD in the dietary management of drug resistant epilepsy and neurometabolic diseases, and global guidelines and resources for its implementation for these conditions are now widely available¹. Use of the KD may also have potential application in cancer and other neurological conditions¹⁵⁻¹⁸.

There are 5 versions of the KD in clinical use worldwide^{1,19}

The classical KD (**CKD**) and medium chain triglyceride KD (**MCTKD**) are the traditional, strict versions of the KD.

'Modified' versions of the KD are also available- the modified Atkins diet (**MAD**); Low Glycaemic Index Treatment (**LGIT**) and modified KD (**MKD**) - which were developed to be less prescriptive, more flexible and accessible approaches for implementation of the original KD. Refer to section 3.0. for details of each variant.

Although there are slight differences in the proportions of macronutrients and how each version is calculated and applied, all are very high in fat, low in carbohydrate, provide adequate protein and are designed to achieve ketosis.

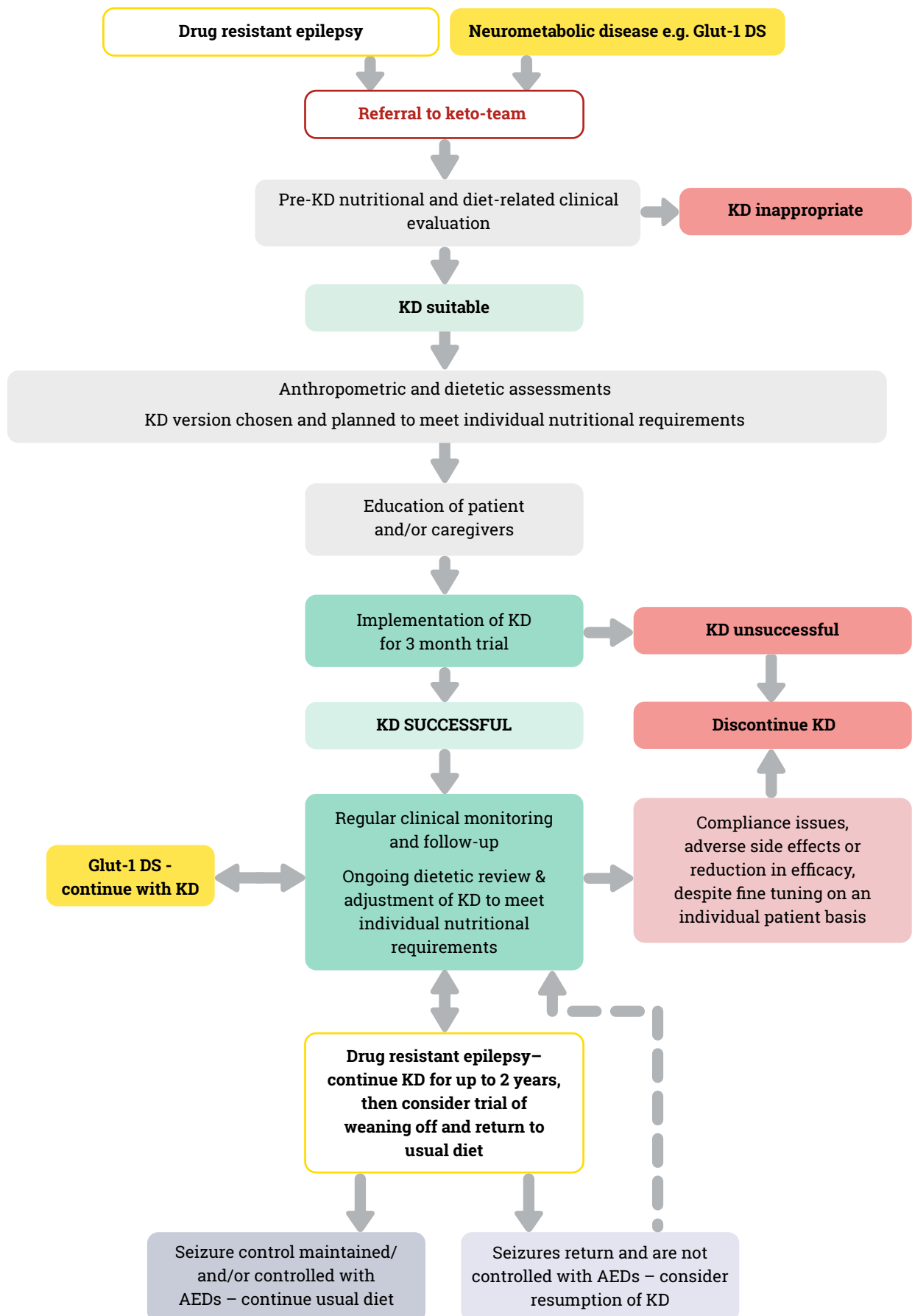
Choice and application of the versions of the KD varies by country, **keto-team**, clinician or dietitian, and is usually based on factors such as history, experience and familiarity of use.

The use and application of the KD is evolving to incorporate the different approaches, features and attributes of each of the versions to optimally meet individual requirements and lifestyle.

An overview of a typical journey for a patient (non-infant) on the KD is shown in **Figure 4**.

Figure 4: The patient (non-infant) journey on the KD

Based on Kossoff et al (2018)¹.



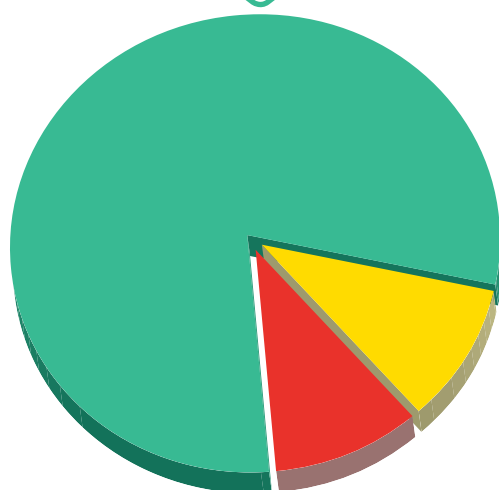
2.0 The KD in more detail, continued

2.2 Foods used in the KD²⁰⁻²³



Principle foods used to supply macronutrients in all versions of the KD and their relative proportions

FAT provides fatty acids for conversion to ketones and should meet the majority of daily energy requirements. Sources are oils, butter, ghee, margarine, mayonnaise, full-fat cream cheese, double (heavy) cream and MCT oil and emulsion.



PROTEIN, ideally from high-biological value (HBV) sources, (meat, poultry, fish, eggs and dairy food) is essential for growth and tissue repair. Plant sources of protein, for example, soya, beans, seeds and nuts can be used provided an adequate amino acid intake is achieved and carbohydrate contribution accounted for.



CARBOHYDRATE mainly from small portions of vegetables and salad, berry fruits, nuts and seeds. These foods also provide **FIBRE**.



Foods very high in carbohydrate are avoided in a KD

- **Foods high in natural or added sugars** e.g. confectionary (candies) and chocolate, dried fruit, fruit juices, sweetened, carbonated drinks and cordials containing sugars, jams, honey, ice cream.
- **Foods high in starch with or without natural or added sugars** e.g. potato chips (french fries) and crisps, cakes, biscuits, puddings, pies and pastry products.





-



This means that in addition to extending the range and choice of foods, favourite or familiar items can be included as part of meals, snacks and as ingredients in recipes. Although portion sizes will be much smaller than typically eaten in a normal diet, even tiny quantities can aid acceptability, palatability and long term compliance with a KD.

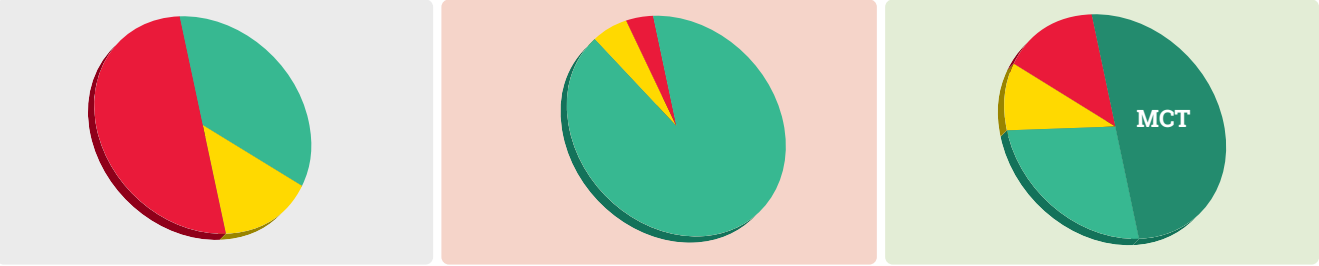


N.B. These may need adapting to suit individual patient dietary requirements.

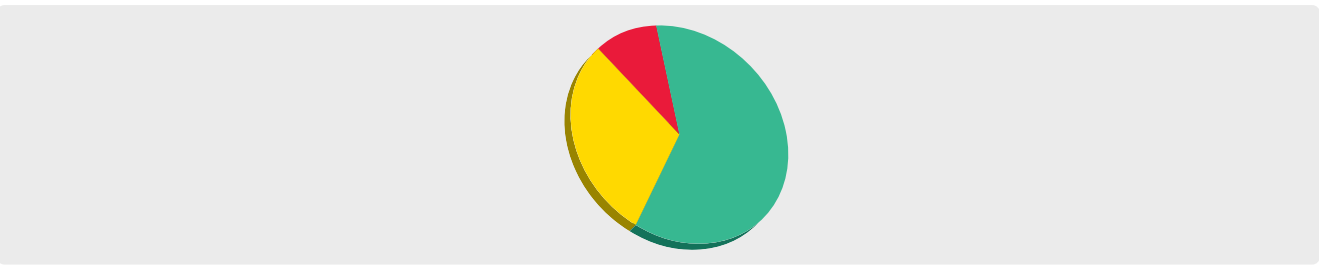
3.0 Comparison of the 5 versions of the KD, and considerations

	Traditional	
Version of the KD (and key references for description and implementation)	CKD ^{1, 3-5, 20, 21}	MCTKD ^{1, 20, 22, 25, 26}
History	<p>The original KD from the 1920's and 30's prior to greater availability of AEDs. Use then declined, but revived during the 1990's.</p> <p>Extensively and successfully used worldwide, especially in young children¹¹.</p>	<p>Developed by Huttenlocher et al²⁶ in the 1970's as a modification of the CKD, using medium chain triglyceride (MCT) oil to replace a proportion of long chain triglycerides (LCT) and take advantage of the greater ketogenic potential of the medium chain fatty acids (MCFA) C8 (octanoic) and C10 (decanoic).</p>
Key points	<p>A ratio expresses the proportion of fat to protein plus carbohydrate combined, by weight in grams.</p> <p>E.g. a 4 to 1 CKD indicates for every 4g of fat there is 1g of protein and carbohydrate combined.</p> <p>Although the higher ratios of 4 to 1 and 3 to 1 are potentially the most ketogenic, a lower ratio of 2 to 1 may be as efficacious for seizure reduction²⁴.</p> <p>Once individual daily energy and protein requirements (which form the basis of the dietary prescription and calculation) are determined, the target ratio is chosen.</p> <p>The amounts of fat, protein and carbohydrate in grams required are calculated, then divided up evenly into meals and snacks so the ketogenic ratio is the same over the day.</p>	<p>The MCTKD has equivalent efficacy to the CKD^{27,28} but in comparison permits:</p> <ul style="list-style-type: none">• Proportionally more carbohydrate and protein to be included• Less total fat• Enhanced palatability. <p>The percentage of total daily energy for LCT, MCT, protein and carbohydrate is used to express macronutrient distribution. 45-50% of energy from MCT is likely to achieve gastrointestinal tolerance and good ketosis but can range from 30 – 70% on an individual basis.</p> <p>Individual energy requirements are determined, % contribution from each macronutrient chosen and used to calculate daily amounts of fat (LCT and MCT), protein and carbohydrate in grams. These can then be converted into food choices (exchanges), distributed into a daily meal plan and used to construct meals and snacks.</p>
Ratio by weight of fat to carbohydrate and protein combined	e.g. 2 to 1, 2.5 to 1, 3 to 1, 4 to 1	Approximately 1.6 to 1

Comparisons of approximate ratio of macronutrients by energy intake from fat, protein and carbohydrate



	Modified		
	LGIT ^{1, 29-31}	MAD ^{1, 33, 34}	MKD ¹⁹
	<p>Developed from observations that:</p> <ul style="list-style-type: none">• Blood glucose levels are stable on the CKD and during fasting.• Diets with a low glycaemic index (GI) are linked with favourable health measures and outcomes³².• Excessive intakes of high GI foods may provoke seizures in some people with epilepsy.	<p>Developed as a result of seizure reduction observed by patients with epilepsy using the low carbohydrate, high protein Atkins diet originally intended for weight reduction.</p>	<p>Has evolved as a 'hybrid' of features from the other 4 versions of the KD, e.g. incorporating MCT, using low GI carbohydrate, and offering a more flexible approach to food selection.</p>
	<p>Only carbohydrate foods (40 – 60g per day including fibre) with a GI of < 50 are permitted.</p> <p>The level of carbohydrate in the LGIT has been chosen to reflect that 50g per day is the physiological maximum below which the body will use fat as its primary energy source.</p> <p>Energy requirements are typically assessed before the diet is started (especially for children), and advice given on protein and fat intakes to ensure consumption of appropriate amounts.</p>	<p>In comparison to the CKD designed to offer:</p> <ul style="list-style-type: none">• Greater flexibility with food choices and with eating away from home.• Increased patient access – useful option for older children, teenagers and adults.• Reduced involvement of keto-team in pre-diet preparation and monitoring. <p>Carbohydrate is very restricted at first to 10g, 15g or 20g per day, depending on age, but can be eaten at any time.</p> <p>Protein can be eaten freely, but may need regulating to promote ketosis if consumed in preference to high fat foods. Energy requirements are not typically assessed beforehand. An 'ad lib' fat intake is encouraged that is sufficient to meet individual energy needs and satisfy appetite.</p>	<p>Carbohydrate content may be more generous than the MAD, e.g. 30-40g per day, typically decided on an individual patient basis depending on dietary efficacy.</p> <p>In comparison to the MAD, individual energy requirements are usually taken into consideration during the planning of the MKD.</p> <p>The food choices (exchange) system may be used for fats and carbohydrates, together with advice on moderation of protein intake. This approach helps ensure macronutrient and energy intakes are appropriate by regulating portion sizes, and provides structure and guidance for food selection and meal planning.</p>
	Approximately 1 to 1.		



3.0 Comparison of the 5 versions of the KD, and considerations, continued



Macro and micronutrients					
	CKD ^{1, 3-5, 20, 21}	MCTKD ^{1, 20, 22, 25, 26}	LGIT ^{1, 29-31}	MAD ^{1, 33, 34}	MKD ¹⁹
Fat - LCT	<ul style="list-style-type: none">Proportionally, intakes of saturates, mono or polyunsaturates will predominate depending on the particular high fat foods most frequently consumed, e.g. saturates from butter and double (heavy) cream, monounsaturates from olive oil use or polyunsaturates from seed oils, e.g. sunflower, safflower or rapeseed (canola).Prudent inclusion of a variety of sources of LCT from both animals and plants, provides a balanced mixture of all three types of fatty acids in the context of cardiovascular and metabolic health³⁵.				
Fat - MCT	Once established on diet, MCT can be introduced and if taken at regular intervals with food (as part of daily meals and snacks) may help 'boost' ketone production without needing to increase the ketogenic ratio ³⁶ .	The amount of MCT calculated for the patient is distributed evenly amongst meals, snacks and at bedtime, i.e. consumed regularly throughout the day, and always with food.	Once established on diet, MCT can be introduced and if taken at regular intervals with food (as part of daily meals and snacks) may help 'boost' ketosis without the need for an increase in LCT or reduction in carbohydrate intake ³⁶ .		
	<ul style="list-style-type: none">Pure coconut oil consists predominantly of C12. Although it can be classed as a MCFA, C8 and C10 are considered to have the greater ketogenic and anti-epileptic potential³⁷⁻⁴⁰.C8 and C10 are predominant in the MCT oils and emulsions available for clinical use and are therefore recommended in preference to coconut oil as a source of MCT and MCFA in the KD.MCT can cause adverse gastrointestinal symptoms, needs to be introduced slowly and carefully, and is best taken with other foods as part of a meal or snack.Further information on the use of MCT in the KD and establishing gastrointestinal tolerance is available for downloading from www.nestlehealthscience.com/Vitaflo/VIAN.B. The MCFA C8 and C10 are saturated. However, evidence suggests they have potentially beneficial health effects in comparison to saturated fatty acids with longer chains³⁵.				
Essential fatty acids (EFA) - omegas 3 and 6	Due to the fats typically consumed in the KD, intakes of omega 3 fatty acids can be below that recommended for health ⁴² . Use of different fat sources provides balance, together with inclusion of vegetable oils (e.g. walnut, flaxseed, linseed) and foods (oily fish, fortified eggs, seeds, nuts and green vegetables) naturally high in omega-3 fatty acids.	EFA's are not present in MCT and intakes can be low. Although some will be provided via LCT, inclusion of oil and food sources of omega 3 is advised, as per the CKD .	As for the CKD .		
Protein	For all versions of the KD, sufficient protein and essential amino acids must be included for growth, function, repair and replacement of body tissues. To ensure adequate intakes: <ul style="list-style-type: none">Include HBV protein (meat, fish, eggs, cheese) in each meal every day.Avoid sole or over-reliance on plant sources of protein (vegetables, tubers, grains, soya, pulses, peas, beans, lentils or nuts) to meet requirements.				
	Intakes must meet minimum safe intake levels ^{42, 43} , especially for individuals on a high ratio diet with low energy requirements.	The quantity of protein permitted is more generous than the CKD which helps with palatability.	A free choice of protein food(s) can be made but moderate intakes are advised, i.e., normal sized portions. If eaten to excess, protein foods, due to their high palatability, may replace those providing fat and compromise ketosis.		
Carbohydrate	Daily carbohydrate intake is influenced by protein and energy needs and diet ratio. E.g. on a higher protein, lower energy, 3 to 1 or 4 to 1 ratio CKD there is less carbohydrate compared to a lower protein, higher energy 2 to 1 ratio. This may influence acceptability and compliance as it affects palatability.	The quantity of carbohydrate permitted is more generous than the CKD which helps with palatability.	40–60 g per day of carbohydrate from foods with a GI of < 50 are permitted daily. N.B. This quantity of carbohydrate includes the fibre content of these foods ³³ .	Very restrictive. Depending on age, 10, 15 or 20g per day initially. After 1 to 3 months this may be increased e.g. up to 25g per day on an individual patient basis, if the MAD proves efficacious ³⁷ .	Very restrictive but may allow a slightly more generous allowance compared to the MAD . Carbohydrate may be adjusted by increasing or decreasing incrementally depending on efficacy.
Micronutrients	Micronutrient content is inherently low and/or inadequate in all versions of the KD.		A comprehensive, daily supplement to meet daily requirements is advised ¹ , or as per keto-team policy.		

4.0 Pre-KD assessments and clinical outcomes¹

The KD is complex and can have side effects. Before a patient is started on a KD, undertake the following:

- Clinical, anthropometric and dietary assessment (4.1 - 4.3).
- Pre-KD clinical and/or dietary intervention, if required (4.1).
- Measurement of clinical outcomes to provide baseline data on the patients current health status. These can then be used as serial assessments to determine change or benefit, e.g. after 3, 6 and 12 months. Specific KD outcome measures may include seizure frequency and severity, dietary adherence, adverse effects, anthropometry, quality of life.
- Obtain commitment from the patient and/or parents/caregivers to follow the KD for the recommended trial period of 3 months to determine its efficacy¹.
- KD training for the patient and/or all involved in their care, e.g. family, teachers, respite care staff.

4.1 Clinical and dietetic assessments

Does your patient currently have this?	To consider...	Action BEFORE starting KD
Gastrointestinal disorder(s) Gastroesophageal reflux (GOR), delayed gastric emptying, oesophageal and foregut dysmotility.	GOR may be aggravated by a high fat diet ⁴⁴ . BUT... ...including MCT in a KD can allow a lower total fat intake ^{1,36} .	Mandatory assessment by specialist feeding and/or gastroenterology team.  Implement recommended strategies and interventions before starting a KD.  Ensure they are successful prior to starting the KD.
Physical feeding problems⁴⁵ Oro-motor impairment causing: <ul style="list-style-type: none"> • Difficulties with chewing, biting & swallowing. • Increased aspiration risk. • Prolonged feeding times. 	The KD has a soft, semi solid texture due to its high fat content. This consistency can be well suited to those with feeding difficulties. A daily pattern of small, frequent meals and snacks, often ideal for those with feeding issues, can also help to achieve and maintain ketosis on the KD. The high energy density of fat means that relative to a normal diet, ketogenic meals and snacks are much smaller in size. This reduction in volume may help those who struggle to consume adequate food by facilitating quicker and more efficient feeding and an improved nutritional intake.	
Behavioural feeding problems⁴⁵ e.g. food refusal, food avoidance, selective or faddy eater.	The restricted range of foods permissible on the KD may suit fussy eaters. Personal and family food preferences can be incorporated into the KD and may aid compliance and acceptance.	

N.B. If any of these issues continue or develop once on the KD, refer for specialist assessment and advice.

Does your patient currently have:	Relevance to the KD	Initiate BEFORE starting a KD
Constipation	Constipation is linked to low dietary fibre and fluid intakes ⁴⁶ . Carbohydrate restriction limits consumption of fibre-containing plant foods such as fruits, vegetables and cereals. In addition, being constipated may be associated with seizures ⁴⁷ .	Advise using KD-compatible foods relatively low in carbohydrate yet high in fibre to promote natural laxation e.g. nuts, seeds (e.g., flax, chia), berry fruits, avocados and certain vegetables, e.g. spinach, mushrooms, broccoli and cauliflower.
Inadequate fluid intake due to poor/unsafe swallow	Low fluid intake on the KD is linked to constipation and urolithiasis ^{48,49} . Foods high in fat are low in moisture. Those that typically contribute water in a normal diet, e.g. vegetables and fruits, are restricted. Thus, the inherent fluid content of a KD is low.	Advise on, and achieve, appropriate and safe fluid intake.
Habitual low fluid intake		
Poor nutritional quality of current diet.	Fat is inherently low in micronutrients; combined with restrictive food choices, the risk of nutritional deficiencies is increased.	Specific micronutrient and/or comprehensive supplementation should be started before the KD commences. Note: daily micronutrient supplementation is recommended for all patients on the KD ¹ .
At risk of/known micronutrient deficiency.		
Food allergies e.g. milk, egg.	All versions of the KD can be given as an exclusion diet, or to meet individual or family dietary choices using preferred and permitted foods.	Ensure correct diagnosis made and food exclusion actually required.
Food intolerance e.g. lactose, wheat.		
Coeliac disease		
Food restrictions, self imposed or cultural e.g. vegetarian, vegan, halal, kosher	N.B. Due to carbohydrate content, quantities of protein foods used in a vegan KD (especially a CKD) e.g. nuts, lentils, beans, soya and quorn, may not provide adequate intakes of the individual essential amino acids needed growth and health.	Ask patient and/or parents/caregivers if they will permit inclusion of animal protein foods to ensure nutritional adequacy of diet.
On full or partial enteral feeding (oral or via a feeding tube)	Commercially produced ketogenic formulas (ready-to-feed liquids or powders for reconstitution) are available. Alternatively, bespoke, modular ketogenic feeds can be calculated to meet individual patient dietary requirements, and prepared from suitable ingredients (including blended foods) ¹ . Ensure parents/caregivers have practiced making up the feed before the KD is started.	
Expectations	Patients and/or parents/caregivers need to be motivated and have decided they definitely want to embark on a KD.	The KD doesn't always work, although for some individuals improvements in seizure management and quality of life may be better than anticipated.
As part of the assessment and pre-KD preparation process, realistic goals for dietary management and clinical outcomes should be discussed and agreed between the keto-team and patient and/or parents/caregivers.		

4.0 Pre-KD Assessment and clinical outcomes, continued

4.2. Anthropometric

Children and adolescents



Weight (kg)

Height (cm)

If aged between 1 and 2 years - head circumference (cm)

Optional - calculate Body Mass Index (BMI).

Plot on a growth chart (along with any historical growth data, if available, for reference).

N.B. Children's growth velocity and expected weight gain may slow on the CKD, especially over time^{1,49}.

Adults



Weight (kg)

Height (m)

Calculate BMI = $\frac{\text{weight in kg}}{\text{height in metres}^2}$

Overweight pre-KD

Some initial weight loss may be beneficial for initiation and maintenance of ketosis at the start of a KD. In children, aim for stabilisation of weight over time to allow for growth.

Underweight pre-KD

Advise on increasing energy intake by adding extra fat into the current diet - both to promote weight gain and to get used to eating more before formally starting the KD.

- Once on the KD, regular anthropometric and dietetic assessment to monitor clinical outcomes is especially important for children and those with pre-existing compromised nutritional status, feeding problems and/or impaired mobility and activity levels, to help ensure dietary intake (particularly of protein) is appropriate.
- If the KD proves effective, seizure reduction may lead to an increase or decrease in energy requirements. Likewise, changes in mobility and activity, e.g. improvements in ambulatory skills, may alter individual needs and impact nutritional status over time.

4.3 Dietary assessment

- For the **CKD** and **MCTKD**, detailed and specific information about current nutritional status and usual diet enables estimation of actual daily energy needs (which may differ from those recommended for age) and calculation of quantities of macronutrients for meals and snacks. This information facilitates practical guidance to be given by the **keto-team** and can help achieve greater success in diet implementation and efficacy¹.
- In comparison, for the modified versions of the KD (**MAD**, **LGIT** or **MKD**), pre-diet evaluation may be less formal.
- Before starting the **MAD**, no diet history is taken from the patient nor are they advised to have a specific daily energy intake^{34, 35}.
- For the **LGIT** and **MKD**, individual energy requirements are usually determined^{19, 29-31}. This is to guide the advice given to the patient on appropriate daily macronutrient intakes (especially fat) to meet these needs, and to promote ketosis.

Examples of dietary assessment tools:

- 3-4 day diet diary filled in by the patient and/or carer
- Verbal diet history (previous 24 hours and/or longer retrospective period) and/or
- Food frequency questionnaire

Dietary assessment identifies:

- Specific details of foods and drinks consumed i.e. those avoided and restricted; textures (important for those with feeding problems), preferred food combinations, flavours, presentations, portion sizes.
- Usual eating and drinking intake, habits and patterns.

- How foods and drinks are prepared, and by whom.
- Sources and availability of foods, eating venues e.g. home and institutions (school, college, respite care), takeaways, cafés, restaurants.

Action points when planning a KD:

Include familiar and favourite foods and drinks where possible to aid compliance.

If **eating habits** are irregular, advise that a consistent daily meal and snack pattern is established pre-KD as this will aid maintenance of ketosis.

Aim to normalise **fluid intakes** as:

- Too little is linked to side effects, e.g. constipation, urolithiasis.

or

- If excessive - especially in young children - this may decrease appetite and food intake, affecting the ability to consume the KD properly and achieve ketosis.

Educate and provide information to all involved in preparing foods, drinks and feeding the patient. This is vital prior to starting a KD.

Give information and advice on making correct food and drink choices when eating out and away from home.

Information gained from clinical, anthropometric and dietetic assessments, and from the patient and/or parents/caregivers, will aid choice of the most suitable version of the KD for them (4.4)¹.

4.0 Assessment and clinical outcomes, continued

4.4. Choosing a version of the KD for your patient¹

Are they one who....?	Suggestion	To consider
Traditional Versions		
<p>Is a younger child.</p> <p>Would prefer a structured format and detailed, precise instructions to follow.</p> <p>Has a poor appetite, can be a fussy or slow eater or self restricts; prefers small meals.</p> <p>Needs an enteral feed taken orally or via a feeding tube.</p>	CKD	<p>Labour intensive - all foods need weighing and measuring and all meals and snacks need calculating.</p> <p>Lots of fat, very little carbohydrate and protein; meals look small.</p>
<p>Is of any age (children, adolescent and adults).</p> <p>Would prefer a structured format and detailed, precise instructions to follow.</p> <p>Likes carbohydrate and protein foods.</p> <p>Needs more protein than achieved from a CKD.</p> <p>Is willing to use a food choices (exchange) system for fat, carbohydrate and protein.</p> <p>Needs an enteral feed taken orally or via a feeding tube.</p>	MCTKD	<p>Labour intensive - all foods need weighing and measuring and all meals and snacks need calculating.</p> <p>MCT is introduced gradually, building up to the required daily quantity. Hence, it may take a while for the MCTKD to be fully tolerated and established before efficacy is determined.</p> <p>Must be prepared to take MCT regularly throughout the day, with food.</p>
Modified Versions *		
<p>Is an older child, adolescent or adult. Needs a less restrictive diet than a CKD or MCTKD i.e. less weighing of foods and more flexibility with food choices and quantities.</p> <p>They and/or their parents/caregivers can cope with a less structured KD.</p> <p>Eats out or is away from home regularly.</p> <p>Wants 'normal sized' and 'normal looking' meals.</p> <p>Willing to use a food choices (exchange) system for fat and carbohydrate to assist with meal planning and portion sizes from the outset or as an aid to compliance.</p>	LGIT	<p>40 - 60g carbohydrate (including fibre) each day from foods with a GI < 50.</p>
	MAD	<p>Very restrictive carbohydrate intake at first.</p>
	MKD	<p>Has the potential to be the most 'tailored' to the patient's nutritional and lifestyle requirements by incorporating elements of the other 4 versions of the KD</p>

LGIT, MAD, MKD

- **High fat and strict low carbohydrate intakes are still required .**
- ***Level of ketosis achievable may be inadequate for very young children with neurometabolic disease, e.g. Glut-1 DS. The CKD or MCTKD may be preferable¹.**

For the KD to be successfully implemented and followed, patients and/or parents/caregivers need the ability and confidence to:

1. Measure foods and portion sizes accurately and consistently.
 - For the **CKD** and **MCTKD**, by using digital electronic scales to weigh foods in grams.
 - For the modified versions of the KD (**LGIT**, **MAD** and **MKD**), using household measures (i.e. spoons, cups) and/or digital electronic scales to weigh foods in grams, as directed by the **keto-team**.
2. Choose, shop for, cook and prepare meals, snacks and recipes from foods as calculated and advised by the **keto-team**.
3. Use information on food labels to help guide the selection and inclusion of foods for meals and snacks, e.g. from:
 - The ingredients list to identify sources of macronutrients, especially carbohydrate and fat.
 - The nutrition information box, to identify amounts of macronutrient per 100g of food, so that specific quantities in grams can be calculated, either as portions or as part of the food choices system²²⁻²⁵.
4. Follow and implement written dietary advice and instructions provided by the **keto-team**.
5. For those on enteral feeds, prepare a KD feed recipe as calculated by the **keto-team**.

Education and resources for the KD can be provided via:

- Face-to-face meetings and teaching sessions, on an individual, family or group basis.
- The telephone, live video conference calls, emails or texts.
- Printed copies of the individual meal plan, meal and snack suggestions and recipes specifically prepared for the patient.
- Opportunity to prepare and try out recipes, meals and snacks beforehand, at home or KD cookery events run by the **keto-team**.
- Information booklets, leaflets, recipes and advice sheets written by the **keto-team** and/or from charities and organisations providing advice and support for the KD when used for epilepsy and neurometabolic disorders, e.g. Matthew's Friends, www.matthewsfriends.org; The Charlie Foundation, www.charliefoundation.org; The Glut-1 Deficiency Foundation, www.gldfoundation.org
- Links to patient-friendly ketogenic diet websites, e.g. www.myketogenicdiet.co.uk
- 'Buddy-ing up' with others who have used, or are using, the KD who are willing to help those new to the diet, by meeting in person, via social media or on the telephone.


- **Provide KD information and training to everyone involved with and caring for the patient, e.g. relatives and friends, education and respite care staff.**
- **Encourage patients/and or caregivers to practice making up meals, snacks and recipes to sample before the KD formally starts, to build confidence in food choice and preparation. A period of preparation beforehand is recommended¹ to promote acceptance of and adherence to the KD - so represents time well spent!**

6.0 Making dietary changes before starting the KD^{1,19}

Changing over to a diet very high in fat and containing minimal carbohydrate is demanding, and requires many lifestyle adjustments by patients and parents/caregivers. In addition to restricted food choices, requisite changes to macronutrient proportions in meals and snacks alters their taste, texture and size. This can compromise tolerance and acceptance of the KD and make implementation more challenging.

To aid this transition, simple alterations can be made to the patients usual diet for a short period, e.g. 1-2 weeks, prior to them starting the KD. Information from the dietetic assessment (Section 4) can help tailor individual advice to avoid compromising energy and nutritional intakes.

Examples of pre-KD dietary changes are:

 **Omit foods and drinks high in sugar**, e.g. sweets, chocolate, cakes, biscuits, puddings, icecream.

- Swap high sugar cordials, fizzy pop and fruit juice to sugar-free varieties or plain water and
- Use sweeteners instead of adding sugar or honey to foods and drinks, or low sugar or sugar free alternatives to sugary yogurts, desserts and breakfast cereals.



Reduce intakes of foods high in starch, e.g potatoes, rice, pasta, bread, cereals, beans and pulses.

- Give practical advice on portion sizes and/or suggest full or partial replacement with low carbohydrate vegetables and salads.
- Milk (whole, semi-skimmed or formula) is generally avoided in the KD, although small amounts can be included in the **MCTKD**. Exchange milk for low carbohydrate, unsweetened soya or nut milks or diluted double (heavy) cream.



Increase fat intake, (ideally from a variety of animal and plant sources, to provide a mixture of saturated, monounsaturated and poly-unsaturated fatty acids) by:

- Frying foods.
- Using full fat dairy products such as Greek yogurt and cheese (both useful as snacks to replace sugary foods).
- Adding extra fat to foods, e.g. butter, margarine, cream cheese or oil to potatoes, vegetables and bread; mayonnaise or oil based dressing to salads, and cream (double or heavy) to fruit, low sugar desserts or yogurt.



In addition, dietary habits that should be established prior to starting a KD are:



Eating meals and snacks regularly during the day. This can help promote a steady and sustained ketosis when on the KD.



Achieving a daily fluid intake that meets individual requirements for hydration. This is important once on the KD, due to its inherent low fluid content.



Taking a daily micronutrient supplement. This is to ensure that despite the restrictive nature of the KD, nutritional requirements will be adequately met.



1. Kossoff EH, Zupec-Kania BA, Auvin S, Ballaban-Gil KR, Christina Bergqvist AG, Blackford R, Buchhalter JR, Caraballo RH, Cross JH, Dahlin MG, Donner EJ. Optimal clinical management of children receiving dietary therapies for epilepsy: Updated recommendations of the International Ketogenic Diet Study Group. *Epilepsia open*. 2018, 3(2):175-92.
2. Hartman, A.L., Rho, J.M. The biochemical basis of dietary therapies for neurological disorders. Chapter 5, pp.34-44. Neal E, editor. *Dietary treatment of epilepsy: practical implementation of ketogenic therapy*. John Wiley & Sons; 2012 Jul 3.
3. Wilder, R. M. 1921. Effects of ketonuria on the cause of epilepsy. *Mayo Clinic Proc*. 2: pp. 307-8.
4. Talbot, F.B., Metcalf, K.M., Moriarty, M.E. 1927. A clinical study of epileptic children treated by the ketogenic diet. *Boston Medical and Surgical Journal*. 196, pp. 89-96.
5. Talbot, F.B. 1930. *Treatment of epilepsy*. New York; Macmillian.
6. Cross, J.H. 2013. New research with diets and epilepsy. *Journal of Child Neurology*. 28(8) pp. 970-4.
7. Rho, J.M., 2017. How does the ketogenic diet induce anti-seizure effects? *Neuroscience Letters*. 637, pp.4-10.
8. Simeone, T.A., Simeone, K.A., Stafstrom, C.E., Rho, J.M., 2018. Do ketone bodies mediate the anti-seizure effects of the ketogenic diet? *Neuropharmacology*. 133, pp.233-241.
9. Fisher, R.S., Acevedo, C., Arzimanoglou, A., Bogacz, A., Cross, J.H., Elger, C.E., Engel Jr, J., Forsgren, L., French, J.A., Glynn, M. and Hesdorffer, D.C., 2014. ILAE official report: a practical clinical definition of epilepsy. *Epilepsia*. 55(4), pp.475-482.
10. Kwan, P., Schachter, S.C. and Brodie, M.J. 2011. Drug-resistant epilepsy. *New England Journal of Medicine*. 365(10), pp.919-926.
11. Martin-McGill, K.J., Jackson, C.F., Bresnahan, R., Levy, R.G., Cooper, P.N. 2018. Ketogenic diets for drug-resistant epilepsy. *Cochrane Database of Systematic Reviews*, (11).
12. Pearson, T.S., Akman, C., Hinton, V.J., Engelstad, K., Darryl, C. 2013. Phenotypic spectrum of glucose transporter type 1 deficiency syndrome (Glut1 DS). *Current Neurology and Neuroscience Reports*. 13(4), p.342.
13. De Vivo, D.C., Trifiletti, R.R., Jacobson, R.I., Ronen, G.M., Behmand, R.A., Harik, S.I. 1991. Defective glucose transport across the blood-brain barrier as a cause of persistent hypoglycorrhachia, seizures, and developmental delay. *New England Journal of Medicine*. 325(10), pp.703-709.
14. Klepper, J., Diefenbach, S., Kohlschütter, A., Voit, T. 2004. Effects of the ketogenic diet in the glucose transporter 1 deficiency syndrome. *Prostaglandins, Leukotrienes and Essential Fatty Acids*. 70(3), pp.321-327.
15. Kossoff, E.H., Hartman, A.L. 2012. Ketogenic diets: new advances for metabolism-based therapies. *Current Opinion in Neurology*. 25(2), p.173.
16. Rho, J.M., Stafstrom, C.E. 2012. The ketogenic diet as a treatment paradigm for diverse neurological disorders. *Frontiers in Pharmacology*. 3, p.59.
17. McDonald, T., Cervenka, M. 2018. The expanding role of ketogenic diets in adult neurological disorders. *Brain Sciences*. 8(8), p.148.
18. Pilla, R. 2018. Clinical Applications of Ketogenic Diet-Induced Ketosis in Neurodegenerative and Metabolism-Related Pathologies. *Nutrition and Food Science Journal*. 2(1), pp. 115-20.
19. Martin-McGill, K.J., Lambert, B., Whiteley, V.J., Wood, S., Neal, E.G., Simpson, Z.R., Schoeler, N.E. and Ketogenic Dietitians Research Network (KDRN), 2019. Understanding the core principles of a 'modified ketogenic diet': a UK and Ireland perspective. *Journal of Human Nutrition and Dietetics*, 32(3), pp.385-390.
20. Fitzsimmons, G., Sewell, M. Ketogenic diets. Chapter 16, p 354. Shaw, V, editor. *Clinical Paediatric Dietetics*. John Wiley & Sons; 2015.

7.0 References, continued

21. Magrath, G, Neal, E. The Classical ketogenic Diet. Chapter 8, pp. 66-77. Neal E, editor. Dietary treatment of epilepsy: practical implementation of ketogenic therapy. John Wiley & Sons; 2012 Jul 3.
22. Neal, E. The medium chain triglyceride ketogenic diet. Chapter 9, pp. 78-88. Neal E, editor. Dietary treatment of epilepsy: practical implementation of ketogenic therapy. John Wiley & Sons; 2012 Jul 3.
23. Magrath, G., Leung, M.A., Randall, T. The modified Atkins diet. Chapter 10, pp. 89-99. Neal E, editor. Dietary treatment of epilepsy: practical implementation of ketogenic therapy. John Wiley & Sons; 2012 Jul 3.
24. Lee, H.F., Chi, C.S. and Liao, J.H. 2018. Use of cooking oils in a 2: 1 ratio classical ketogenic diet for intractable pediatric epilepsy: long-term effectiveness and tolerability. *Epilepsy Research*. 147, pp.75-79.
25. Liu, Y-M.C. 2008. Medium chain triglyceride (MCT) ketogenic therapy. *Epilepsia*. 49: suppl 8, pp. 33-6.
26. Huttenlocher, P. R., Wilbourn, A. J., Signore, J. M. 1971. Medium-chain triglycerides as a therapy for intractable childhood epilepsy. *Neurology*. 21 (11): pp. 1097-1103.
27. Neal EG, Chaffe H, Schwartz RH, Lawson MS, Edwards N, Fitzsimmons G, Whitney A, Cross JH. 2008. The ketogenic diet for the treatment of childhood epilepsy: a randomised controlled trial. *The Lancet Neurology*. Jun 1;7(6), pp. 500- 6.
28. Liu, Y-M.C., Wang, H.S. 2013. Medium chain triglyceride ketogenic diets, an effective treatment for drug resistant epilepsy and a comparison with other ketogenic diets. *Biomed. J.*, 36, pp. 9-15.
29. Pfeifer HH, Thiele EA. 2005. Low-glycemic-index treatment: A liberalized ketogenic diet for treatment of intractable epilepsy. *Neurology*. 65 (11), pp. 1810-2.
30. Muzykewicz DA, Lyczkowski DA, Memon N, Conant KD, Pfeifer HH, Thiele EA. 2009. Efficacy, safety, and tolerability of the low glycemic index treatment in pediatric epilepsy. *Epilepsia*. 50 (5), pp. 1118-26.
31. Pfeiffer HH. The Low Glycaemic Index Treatment. Chapter 11, pp. 100-108. Neal E, editor. Dietary treatment of epilepsy: practical implementation of ketogenic therapy. John Wiley & Sons; 2012 Jul 3.
32. Livesey G, Taylor R, Hulshof T, Howlett J. 2008. Glycemic response and health - a systematic review and metaanalysis: relations between dietary glycemic properties and health outcomes. *The American Journal of Clinical Nutrition*. 87(1), pp. 258S-68S.
33. Kossoff, E.H., McGrogan, J.R., Bluml, R.M., Pillas, D.J., Rubenstein, J.E. and Vining, E.P., 2006. A modified Atkins diet is effective for the treatment of intractable pediatric epilepsy. *Epilepsia*, 47(2), pp.421-424.
34. Cervenka, M.C., Henry, B.J., Kossoff, E.H., Turner, Z. The ketogenic and modified Atkins diets: treatments for epilepsy and other disorders. Springer Publishing Company; 2016.
35. Bhavsar, N. and St-Onge, M.P., 2016. The diverse nature of saturated fats and the case of medium-chain triglycerides: how one recommendation may not fit all. *Current opinion in clinical nutrition and metabolic care*, 19(2), pp.81-87.
36. Magrath, G. Fine tuning. Chapter 17, pp. 149-158. Neal E, editor. Dietary treatment of epilepsy: practical implementation of ketogenic therapy. John Wiley & Sons; 2012 Jul 3.
37. St-Pierre, V., Vandenberghe, C., Lowry, C.M., Fortier, M., Castellano, C.A., Wagner, R. and Cunnane, S.C., 2019. Plasma ketone and medium chain fatty acid response in humans consuming different medium chain triglycerides during a metabolic study day. *Frontiers in Nutrition*, 6.
38. Vandenberghe, C., St-Pierre, V., Pierotti, T., Fortier, M., Castellano, C.A. and Cunnane, S.C., 2017. Tricaprylin alone increases plasma Ketone response more than coconut oil or other medium-chain triglycerides: an acute crossover study in healthy adults. *Current developments in nutrition*, 1(4), p.e000257.
39. Augustin K, Khabbush A, Williams S, et al. Mechanisms of action for the medium-chain triglyceride ketogenic diet in neurological and metabolic disorders. *Lancet Neurol* 2018; 17(1): 84–93.

40. Khabbush A, Orford M, Tsai YC, et al. Neuronal decanoic acid oxidation is markedly lower than that of octanoic acid: A mechanistic insight into the medium-chain triglyceride ketogenic diet. *Epilepsia* 2017; 58(8): 1423–29.
41. EFSA (European Food Safety Authority). 2017. Dietary reference values for nutrients: Summary report. EFSA supporting publication. e15121. 92 pp. doi: 10.2903/sp.efsa
42. World Health Organisation (WHO). 2007. Tables 46 and 47, Chapter 14 in 'WHO Technical Report Series 935. Protein and Amino Acid Requirements in Human Nutrition.' Report of a Joint WHO/FAO/UNU Expert Consultation. Geneva, Switzerland. Available at: http://apps.who.int/iris/bitstream/10665/43411/1/WHO_TRS_935_eng.pdf
43. European Food Safety Authority (EFSA). 2012. Panel on Dietetic products, Nutrition and Allergies. Scientific Opinion on Dietary Reference Values for protein. *EFSA Journal*: *EFSA Journal*, 10(2):2557. Available at: <http://onlinelibrary.wiley.com/doi/10.2903/j.efsa.2012.2557/epdf>
44. Kang HC, Chung DE, Kim DW, Kim HD. 2004. Early- and late-onset complications of the ketogenic diet for intractable epilepsy. *Epilepsia*. 45 (9), pp. 1116-23.
45. Lambert, B., Leung M-A. 2012. The challenge of therapeutic diets in children with pre-existing feeding problems. Chapter 7, pp. 58-65. Neal E, editor. *Dietary treatment of epilepsy: practical implementation of ketogenic therapy*. John Wiley & Sons; 2012 Jul 3.
46. Rajindrajith S, Devanarayana NM. 2011. Constipation in children: novel insight into epidemiology, pathophysiology and management. *Journal of Neuro-gastroenterology and Motility*. 17 (1), p35.
47. Moezi L, Pirsalami F, Inaloo S. 2015. Constipation enhances the propensity to seizure in pentylenetetrazole-induced seizure models of mice. *Epilepsy & Behavior*. 44, pp. 200-6.
48. Furth, S.L., Casey, J.C., Pyzik, P.L., Neu, A.M., Docimo, S.G., Vining, E.P., Freeman, J.M. and Fivush, B.A., 2000. Risk factors for urolithiasis in children on the ketogenic diet. *Pediatric nephrology*, 15(1-2), pp.125-128.
49. Neal E. 2012. Monitoring and side effects. Chapter 18, pp149 - 158. Neal E, editor. *Dietary treatment of epilepsy: practical implementation of ketogenic therapy*. John Wiley & Sons; 2012 Jul 3.



Innovation in Nutrition

A Nestlé Health Science Company

Vitaflo International Ltd,
Suite 1.11, South Harrington Building,
182 Sefton Street, Brunswick Business Park,
Liverpool L3 4BQ, UK

+44 (0)151 709 9020

www.vitaflo-VIA.com

 **Follow Vitaflo Dietitians on Twitter: @VitafloRDs**

® Reg. Trademarks of Société des Produits Nestlé S.A.

© Société des Produits Nestlé S.A.