Case Study:
Enteral formula: Selecting the right formula for your patient

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The availability of various enteral formulae on the market assists in the individualized management of patients. It provides variety in terms of macronutrient content, fluid options and the addition or omission of certain components, e.g. fibre, electrolytes and immunonutrients. It is imperative that health care practitioners should be familiar with all products locally available and should have the ability to select the most appropriate products to meet the patient's needs. We provide a brief summary of all enteral formulae in terms of unique features and recommendations for use. Practical application is discussed by means of two case studies.

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Introduction

A great variety of enteral formulae is available and it can become quite a challenge to decide on the most appropriate formula to prescribe for one's patients at all times. Various classification systems can be used, but ultimately the following categories are primarily of the essence: polymeric, semi-elemental; disease-specific (which can be polymeric or semi-elemental) and modular[1] (Figure 1). When deciding on the correct formula for a specific patient many factors need to be considered, and include both patient and formula related factors.[1]

Polymeric formulae

Polymeric formulae require normal digestion and absorption processes within the gastrointestinal tract (GIT) and macronutrients are used in intact form.[2] These formulae are balanced (meeting 100% RDA) for most micronutrients when between 1-1.5 litres of a given product is consumed daily.[1-3]

Within the polymeric formula range there are wide variations with regard to energy and protein concentration, carbohydrate and fat content, as well as fibre content. The fluid content of a specific formula is affected by the concentration of macronutrients (Table 1).

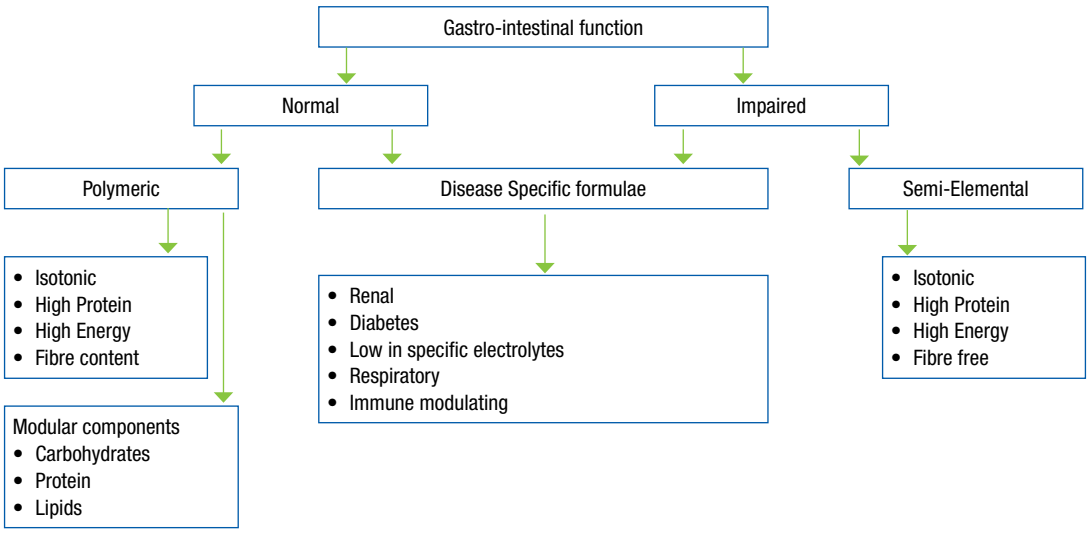

Figure 1. Enteral formula classification

Table 1: Summary of characteristics of enteral formulae and recommendations for use[1,2,3,4,6]

Category	Characteristics	Recommended usage
Polymeric	• Mimics macronutrients as found in whole food • Available with different energy densities (1–2 kCal/ml) • Available with different protein contents (40– 100 g/ litre) • Available with or without fibre • Meets RDA for micronutrients in 1–1.5 litres/day	• Isotonic, polymeric formulae is regarded as a safe option when initiating enteral feeding • For use in patient populations without malabsorptive disorders • High energy and protein formulae for use in patients with enhanced requirements • High energy and protein formulae for use in fluid restricted patients • Fibre could decrease the incidence of diarrhoea and improve gut microbiota • Fibre could play a beneficial role in blood glucose control • Fibre-containing products are recommended for patients receiving long-term enteral formula to prevent and treat constipation
Elemental or semi-elemental	• Macronutrients are hydrolysed to aid in absorption • Available in different energy and protein densities	• Patients with impaired GIT functioning/malabsorption • Patients post GIT surgery with reduced absorptive area and/or prolonged bowel rest • Patients with a chyle leak • Patients with pancreatic dysfunction • Patients with severe malnutrition and hypoalbuminemia, with resultant gut oedema and malabsorption
Diabetes	• Modified macronutrient composition to promote glycaemic control • Higher fat content and fibre to slow gastric emptying and prevent hyperglycaemic episodes	• Could be used for patients with Diabetes Mellitus, if adequate blood glucose control cannot be achieved through standard polymeric formulae • Be cautious of the high fibre and fat content of the products in patients with gastroparesis
Low sodium	• Polymeric formulae with reduced sodium content	• For use in patients with persistent hypernatremia
Renal	• Higher energy and protein content to limit excessive fluid administration • Contain lower amounts of electrolytes, specifically potassium and phosphorus • Available in different protein contents	• Most patients with renal impairment can be managed by standard polymeric products with additional protein content • Persistent electrolyte abnormalities that cannot be managed by standard enteral formulae require specialized renal formulae
Respiratory	• Modified macronutrient content to reduce carbon dioxide production. • Contains omega-3 fatty acids for their anti-inflammatory properties.	• Should be used with caution in critically ill, septic patients, due to the immunonutritional components added • Can be used for patients where efforts to manage respiratory quotient (excess carbon dioxide production) have been unsuccessful • Care should be taken not to overfeed patients
Oncology / immune modulating	• Contains pharmacologically active substances aimed at modulating the immune response and improving outcome	• Potential benefit in patients undergoing elective surgery, however cannot be recommended for routine use among critically ill patients

RDA = Recommended daily allowance; GIT = Gastro-intestinal tract

Semi-elemental formulae

To assist with the digestion and absorption of nutrients, semi-elemental formulae contain macronutrients that are hydrolyzed (partially or fully).[1,3,4,5] These products will typically be used for patients with an impaired GIT (surgery or disease affecting the total available surface length, or exocrine pancreatic insufficiency).[3,4] Although these products are not intended for routine use,[1,2,3,4,6,7] patients with severe malnutrition and hypoalbuminemia where GIT oedema and resultant malabsorption is expected, as well as patients with GIT impairment and patients who did not tolerate (failed management) a polymeric formula will likely benefit from semi-elemental enteral products[1,4] (Table 1).

Disease-specific formulae

Specialized enteral formulae comprise of a wide range of formulae tailored for a variety of clinical scenarios. The aim is to improve patient outcome. However, this might not always be supported by scientific evidence.[1] It should be noted that a wider range of disease specific enteral formulae exists in the international market than what is available in the South African context. For the purpose of this case study we will only refer to products available for use in South Africa (Table 1).

Diabetes Mellitus (DM)

Enteral formulae can be used to assist in glucose control of patients. This can be achieved through the addition of fibre to a polymeric formula, or through strict calculation of the macronutrient composition of the desired product. Products specifically marketed for glucose control are based on a more or less equal carbohydrate to fat ratio or a lower carbohydrate, higher fat content.[1,3,8,9] Emphasis is also placed on the type of fat (mono-unsaturated fatty acids), the addition of fibre (usually a blend of different fibres) and the addition of selected micronutrients (chromium, antioxidants).[1,3,4,8,9] The rationale is that the addition of the fibre and fat will assist in glucose management by controlling gastric emptying, as well as the rate of absorption of glucose throughout the GIT.[3] This approach might be desired in a patient with normal GIT function, but could worsen symptoms of poor enteral feed tolerance in a patient with gastroparesis.[3,4,5] The practice recommendations for macronutrient distribution in the management of DM have changed in recent years with an emphasis on total energy

control and less focus on the specific macronutrient composition.[10] The composition of the enteral formulae available is thus not in line with current recommendations.[1,3] This will however not cause harm as long as the patient is not overfed and is adequately monitored. The use of specialized diabetes enteral formulae is recommended by some[9]; others, however, advocate standard polymeric formulae, preferably with fibre as suitable for use as enteral formula in patients with DM.[1,8] It remains of paramount importance though, in clinical practice, to carry out daily monitoring and adjustment of the formula until adequate blood glucose control is achieved.

Renal

Many factors affect the medical and nutritional management of a patient with renal impairment. Protein, sodium, potassium, phosphorus and fluid restriction need to be considered. Enteral formulae marketed specifically for patients with renal impairment address these aspects by either decreasing or increasing the respective nutrients within a given volume.[1,3,4,5] It remains the responsibility of the health practitioner to select the most suited product considering all relevant aspects. In the majority of cases, standard polymeric formulae could be used as the first line of management. However, persistence of a specific electrolyte abnormality necessitates the use of a relevant renal formula until the abnormality resolves.[1,3]

Pulmonary

The basis of nutrient manipulations in pulmonary formulae are centred around lessening the amount of carbon dioxide production in an effort to reduce the respiratory quotient (RQ).[1] Since carbohydrates contribute the most to RQ, these products decrease the carbohydrate contribution (± 30%) and increase the amount of fat (± 50%), with relatively similar protein contents.[3,4] Another specific component of pulmonary products is the fatty acid composition used. The addition of omega-3 fatty acids, as well as gamma-linolenic acid (GLA) reflect an attempt to enhance the anti-inflammatory properties of products for use in patients with acute lung injury (ALI) and acute respiratory distress syndrome (ARDS).[3,4] Conflicting data exist on the clinical benefit of these formulae.[1,6,7] The practice of manipulating the macronutrient contribution in assisting with weaning patients from a ventilator is, however, no longer regarded as the best manner to achieve these outcomes. Prevention of overfeeding by decreasing the total energy prescribed has been shown to achieve similar results.[1,3,4,6] Therefore, a standard polymeric formula, with possibly less volume, is regarded as the recommended approach.[1]

Immunonutrition

Immune modulating formulae, or immunonutrition, refers to products that contain pharmacologically active substances such as glutamine, arginine, omega-3 fatty acids and antioxidants, amongst others. In this case the goal of enteral nutrition is not only to provide sufficient macro- and micronutrients, but also to modulate the immune system to improve outcome. These products are mainly recommended for use in elective surgery patients. The data is not sufficient to recommend routine use among critically ill patients.[1,3] Recommendations on the use of these products differ between patient populations, the specific pharmaco-nutrient(s) added and different guidelines by various Societies. Discussion of these different guidelines is beyond the scope of the objectives of this clinical practice presentation.

Modular formulae

Single-nutrient products (protein, carbohydrate and fat modules) are available. These are mainly used to enrich existing formula,[1] (e.g. adding additional protein to an existing product), but can also be used to create a tube feed from individual modular components, with the addition of required micronutrients. It is important to ensure that good hygiene principles are employed when modular components are added to existing formula or used to make up a tube feed.

Introduction to cases

Two different case studies will be used as examples. The various categories of products (as available in South Africa) illustrate the thought process underlying the enteral feed selection. Although these guidelines can be used as default recommendations, ultimately disease-specific recommendations must be employed where applicable.

Case 1:

Mr K is a 62-year-old male transferred to the intensive care unit (ICU) from a peripheral hospital with respiratory failure and prolonged ventilation. He underwent a laparotomy 17 days prior to transfer due to colonic obstruction. At laparotomy he was found to have a gangrenous caecum and a right hemi-colectomy was performed, with an end-ileostomy and mucus fistula. On presentation in ICU he was found to have skin dehiscence of the laparotomy wound, but the sheath was intact.

Anthropometry on admission was based on height derived from ulnar length and an estimated body mass index (BMI) and weight. Height: 1.72 m Weight: 80 kg BMI: 27 kg/m^2. Ideal body weight was calculated as 74 kg at a BMI of 25 kg/m^2.

Relevant biochemistry is presented in Table 2. The patient presented with acute kidney injury but was not yet referred for renal replacement therapy (RRT).

On clinical examination the patient was intubated and ventilated and required inotropic support. He had oedematous extremities and pulmonary oedema. Abdominal examination revealed a dehisced skin incision with a vacuum dressing and minimal output. The stoma in the left lower quadrant had no output since admission. The nasogastric tube had minimal drainage of 10 ml.

The patient's recent dietary history was unclear from the referring hospital. There was concern regarding enteral tolerance and it was decided to start parenteral nutrition (PN) due to the fact that he already had a prolonged ICU stay. Enteral nutrition (EN) was also initiated at a low rate.

Table 2:Case 1 Biochemical results

	Unit	Normal	Admission	Day 1	Day 3	Day 9	Day 10	Day 11	Day 22	Day 28
Sodium	**mmol/l**	**136 – 145**	139	139	139	152	156	160	148	144
Potassium	**mmol/l**	**3.5 – 5.1**	3.2	3.7	4.1	3.7	3.6	3.4	3.5	4.2
Urea	**mmol/l**	**2.1 – 7.1**	21.2	24	28.7	13.6	13.6	9.8	8.4	10.7
Creatinine	**umol/l**	**64 – 104**	360	318	364	127	127	107	65	64
Magnesium	**mmol/l**	**0.6 – 1.05**	0.76	0.88	0.98	-	-	-	-	0.8
Phosphate	**mmol/l**	**0.78 – 1.42**	1.71	1.28	1.57	-	-	-	-	1.23
Albumin	**g/l**	**35 - 55**	17							

Requirements were calculated using the European Society for Clinical Nutrition and Metabolism (ESPEN) ICU guidelines[7] of 25–30 kCal/kg total energy (TE), while protein requirements were calculated at 1.2–1.5 g/kg. Ideal body weight was used in the calculations. This amounted to 1850–2220 kCal TE and 89–111 g protein.

The patient's immediate ICU course was complicated by poor EN tolerance but on day three post admission he was weaned off PN onto a concentrated semi-elemental enteral formula providing 1.3 kCal/ml and 67 g protein/L @ 63 ml/hr (1500 ml per day). This provided 1950 kCal TE and 100 g protein. The choice of semi-elemental formula was made on the basis of severe fluid overload with clinical oedema on the background of hypoalbuminemia and a prolonged period of little to no enteral stimulation. The assumption was made that the patient might have gut oedema and poor tolerance of polymeric enteral formula. Due to the renal failure and low urine output the patient was fluid restricted which necessitated the use of a concentrated enteral formula in order to meet calculated requirements.

On day three post admission the patient's renal function deteriorated further and RRT was started in the form of intermittent haemodialysis (IDH). Protein requirements were recalculated using the American Society for Parenteral and Enteral Nutrition (ASPEN) guideline[6] taking into consideration RRT at 1.5–2.5 g/kg depending on the mode of dialysis. Protein goal was set at 111–185 g protein per day. The patient was however fluid restricted to 1500 ml of enteral formula and was already receiving the most concentrated, highest protein containing semi-elemental formula available in the institution. Protein requirement could therefore not be met. Feed was continued at 63 ml/hr as described above. The patient required one day of dialysis only.

Daily review of the biochemical parameters revealed a steady increase in the patient's serum sodium level reaching 152 mmol/L by day 9. The patient was started on additional water at 21 ml/hr via the nasogastric tube while EN continued at 63 ml/hr. This was initiated on the assumption that the patient could be dehydrated due to conservative fluid management. Serum sodium however remained on an increasing trend. The stoma output was well controlled and remained well below 1000 ml per day. In the light of the electrolyte abnormality and the clinical picture, the decision was made to challenge the patient with a low sodium content polymeric formula. The EN prescription was changed to 500 ml of a polymeric enteral product providing 1.5 kCal/ml, 100 g protein/L, and 21 mmol sodium/L with an additional 1500 ml of a polymeric enteral product providing 1 kCal/ml, 40 g protein/L, and 11 mmol sodium/L. The total prescription provided 2000 ml, 2250 kCal TE, 110 g protein and 27 mmol sodium. He remained on this prescription for 19 days before his sodium normalised. Patients with renal dysfunction should not be managed on low electrolyte formula routinely. However, should a specific electrolyte abnormality occur, like in this case, an appropriate formula should be considered to correct it.

Case 2:

Mr X is a 20-year-old male admitted to ICU post sternotomy for a single stab to the chest. He required intubation and ventilation for airway protection due to facial swelling secondary to venous occlusion. Oesophageal injury was excluded. He had no previous medical history of note and was a healthy, fit individual according to information obtained from his family.

Anthropometry on admission was an estimated weight of 63 kg, height (derived from ulnar length) of 1.65 m and a BMI of 23 kg/m^2. Biochemistry was essentially normal. On clinical examination the patient was intubated and ventilated, but awake and able to respond. He was kept intubated due to severe facial swelling. His abdomen was soft and unremarkable.

From a dietary point of few he was started on naso-gastric feeds and increased to 84 ml/h of a polymeric feed over the first 48 hours of ICU admission providing 1 kCal/ml and 38 g protein/L. This provided a total of 2000 kCal and 76 g protein. It is recommended that standard polymeric formula be used when initiating enteral feeding in most patients.[1,6,7] The nutritional requirements were calculated using the ASPEN guidelines[6] for ICU of 25–30 kCal/kg TE and 1.2–2 g/kg protein. Actual body weight was used in the calculations and came to 1575 – 1890 kCal TE and 76–126 g protein. Due to the facial swelling a decision was made to reduce his total fluid volume and his feed volume was restricted to 1500 ml per day.

In order to meet his calculated requirements in the reduced volume, his enteral feed prescription was changed on day 3 post admission. The script included 500 ml of a polymeric enteral feed formula that provides 1.5 kCal/ml and 100 g protein/L combined with 1000 ml of a polymeric enteral feed formula that provided 1 kCal/ml and 38 g protein/L. The combination of formula provided 1750 kCal TE and 88 g protein in the allowed 1500 ml, meeting calculated requirements. Adding additional protein to standard polymeric feeds

has the advantage of meeting patients' nutritional requirements, without having to increase the total amount of feed delivered. When prescribing high protein formulae it is important to monitor renal function and hydration status. A high protein load could result in an increased free water excretion, hypertonic dehydration and hypernatremia. The advantages of higher concentration feeds are that less volume is required to meet individual patient needs. Therefore, patients with high nutritional requirements, in combination with fluid restriction, as well as patients receiving enteral feeds over less than 24 hours, can benefit from using concentrated feeds.[1,3] A potential side-effect of a concentrated feed is a tendency to draw water into the GIT due to the osmotic effect of a high concentration solution. This can result in osmotic diarrhoea.[2]

On day 4 post admission there was a slight improvement in his facial swelling. Examination of his upper airway under sedation however revealed on-going swelling and inability to safely extubate. He was considered for a percutaneous tracheostomy for prolonged ventilation and his feed was discontinued the next morning for the procedure. He developed a temperature of 38°C possibly secondary to ventilator associated pneumonia. His enteral feed was recommenced after placement of the tracheostomy and was restarted at an increased rate of 84 ml/hr to compensate for the time that he was kept nil per os (NPO). Follow-up on day five post admission revealed that he received 1350 ml of his prescribed 1500 ml of enteral formula in previous 24 hours. It was noted that the patient had not passed any stools since admission to ICU. His abdomen was slightly distended but soft and not tender. A decision was made to increase the fibre content of his enteral formula due to the fact that he was expected to be a long term enterally fed patient. He was kept on the 500 ml of enteral formula providing 1.5 kCal/ml and 100 g protein/L since it also included 12 g of 100% soluble fibre per litre. The 1000 ml of standard polymeric formulae was changed to a fibre containing formula, which provided 1 kCal/ml, 38 g protein/L and 15 g fibre/L (Soluble:Insoluble 61:39). This provided a total amount of 21 g of fibre. On day 7 post admission the patient had passed two soft stools and his abdominal distention resolved. He was continued on this prescription for another three days before he was safely extubated and transitioned to oral nutrition.

The fibre content of the various products ranges from none to 20 g/L. Usually a blend of different fibres (soluble, insoluble and prebiotics) is used to ensure best results.[2] The type and amount of fibre should be selected based on the individual patient's needs. Soluble fibre is best prescribed for patients suffering from osmotic diarrhoea, since soluble fibre has the ability to absorb water and form the stool bulk.[2] On the other hand, insoluble fibre is not digested and increases faecal weight,[1,2] which is important for the management of constipation. Fermentation also results in the formation of short-chain fatty acids (SCFA), which provides the main energy source for the colonocytes, and thus aid in the establishment of a healthy microbiome environment.[1,2,4] The fermentation process can aid in gas production, which can cause abdominal distension and discomfort.[1] It should be ensured that the fibre content of feeds is increased gradually, and that sufficient fluid is consumed with a fibre-containing formula.[4] Fibre can also assist in maintaining of blood glucose levels.[4] By combining different fibre types, the enteral formula has the ability to perform various positive effects simultaneously. It is also important to remember that the digestion of fibre is a metabolic process that requires adequate blood supply and a healthy gut. In patients with haemodynamic instability and in the presence of hypotension, it is not advisable to prescribe fibre due to the danger of ischaemic damage to the small bowel.[2-4,6] For this reason, many patients in ICU, especially during the first few days of treatment, should not receive a fibre-containing formula.[6]

Conclusion

There are various factors to consider when selecting an appropriate enteral formula. It is important to evaluate each patient individually and to make evidence-based decisions. Patient-specific nutritional and medical requirements are of the utmost importance. However,

Table 3. Factors to consider when selecting the most appropriate enteral formula

Category	Sub-category	Specific component
Patient related	Medical situation	• Medical history and management • Surgery, especially related to GIT
	Nutrition status assessment	• Presence of malnutrition • Food allergies • Period of nil per mouth
	Management of complications	• Disease-specific requirements • Biochemical abnormalities • GIT malabsorption / diarrhoea / constipation
Nutritional prescription	Access routes	• Naso/oro gastric versus small bowel access
	Nutritional requirements	• Total energy and macronutrient distribution • Fibre needs • Micronutrient needs • Total fluid requirements
Implementation of feed	Administration method	• Continuous over 24 hours versus cyclic over 18 hours versus bolus feeds • Availability of feeding pumps
Logistical matters	Available resources	• Budget • Tender specifications / restrictions • Available staff • Mixing facilities

logistical aspects including cost, availability of resources and tender specifications cannot be ignored (Table 3). It should also be kept in mind that it can become quite a challenge to select the best product in the correct amount(s), meeting nutritional requirements at all times.

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