REVIEW

Enteral feeding. Nasogastric, nasojejunal, percutaneous endoscopic gastrostomy, or jejunostomy: its indications and limitations

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The following article is intended to provide a review of the current state of enteral feeding; a rapidly changing and developing field. It covers the type of feed, the routes of access, and the problems that can occur with enteral feeding.

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Malnutrition is a common problem affecting up to 40% of hospitalised patients, increasing their morbidity and mortality. The problem of malnutrition is often not recognised, and patients can often remain malnourished throughout their hospital stay.[1] Malnutrition develops when metabolic requirements exceed intake, and can develop due to reduced nutritional intake, increased nutrient requirement, or altered ability to utilise or absorb nutrients.

A patient's gross nutritional state is most easily assessed by measuring his or her weight and height and calculating the body mass index (BMI; body weight divided by square of the person's height). Optimal BMI is 20–25 kg/m^2. A BMI of less than 20 kg/m^2 suggests that undernutrition is possible and values below 18 kg/m^2 that it is likely. Mortality is higher, particularly in elderly people, in those with a BMI of less than 18 kg/m^2.

The relationship between nutrition and disease is important, and may affect recovery from illness, surgery, or injury. Infections can be more serious in the presence of malnutrition, and many infections precipitate malnutrition. Malnutrition can result in apathy, depression, fatigue, and loss of morale and can decrease a patient's ability to cooperate in his or her management.[2] In a classic study, healthy male volunteers who lost 25% of their weight after deliberate semistarvation for 24 weeks became depressed, anxious, irritable, and apathetic; they also lost muscle strength and physical capacity.[3]

The majority of recent research on the effects of malnutrition has been carried out in surgical patients. Malnutrition can result in poor postoperative results, impaired and delayed wound healing, and a higher incidence of postoperative complications.[4,5] For these reasons, disease related malnutrition might contribute to increased mortality, morbidity, and length of stay in hospital.[6] Malnutrition results in impaired cardiac function and in weak muscles that fatigue more easily, including respiratory muscles.[7] Cardiorespiratory dysfunction from malnutrition increases the risk of chest infection[8] and limits mobility, predisposing to thromboembolism and pressure sores. However, treating malnutrition can itself cause complications, which partly depends on the route of access.

- Malnutrition is a common problem with potentially serious consequences that is often not recognised.
- Malnutrition affects recovery from surgery or illness, and increases the incidence and severity of infection.
- Supplemental enteral nutrition may be given either by drink supplements or via feeding tubes.

Enteral nutrition can be provided in the form of drink supplements, or if a patient is unable to take adequate nutritional supplements orally, fed via an enteral tube into the stomach or small bowel. There are several different methods of enteral tube feeding, but most short term tube fed enteral nutrition should be given via a nasogastric tube.

Patients are suitable for longer term enteral nutrition if they have a functioning and accessible gastrointestinal tract. Patients include those with swallowing disorders, such as motor neurone disease, multiple sclerosis, those with physical obstruction to swallowing, such as oesophageal tumours, those unable to ingest food, such as head injury or stroke patients, and those with anorexia due to an underlying disease, such as chronic lung disease, irritable bowel disease, or cancer. Dysphagic patients and those with anorexia, malabsorption, or excessive catabolism may also need long term enteral feeding.

Throughout the article and including above, in the interest of readability and as it is still the most commonly used term, we have used the word malnutrition to describe what purists would argue should be called undernutrition or protein energy malnutrition.

TYPES OF ENTERAL FEED

Blenderised food

This is used in many developing countries primarily because it is cheaper than commercially prepared feeds, although is generally not used in the developed world. It is viscous and chunks of

Abbreviations: BMI, body mass index; PEG, percutaneous endoscopic gastrostomy; PEGJ, percutaneous gastrojejunostomy

- Although blenderised feed may be used, generally commercially prepared polymeric feed is most commonly given to patients.
- Elemental and disease specific feeds are increasing in use, but at the moment are principally research based.

food may block the feeding tube and although larger bore tubes can be used, this increases the risk of complications. Patients with digestion and absorption defects may benefit from predigested nutrients.[9] Feed contamination, which is discussed later on in this review, is a further reason why blenderised feed is not used, particularly in immunocompromised patients or those patients with achlorhydria. Clearly feed of this type is unsuitable for jejunal feeding.

Commercially prepared enteral feeds

Polymeric feeds

Polymeric feeds are available with a variety of energy, protein, fat, mineral, vitamin, fibre, and water contents and are suitable for those with a normal or near normally functioning bowel. They contain whole protein as the nitrogen source—most provide 500 g/l of nitrogen and energy of 1 kcal/ml, although they can range from 0.5–2 kcal/ml. Commercial feeds are now clinically lactose and gluten-free and contain enough vitamins, trace elements, and essential fatty acids to prevent deficiencies. Some patients may need extra micronutrients and macronutrients.[9]

Elemental feeds

Elemental feeds contain either pure amino acids or predigested protein and provide oligopeptides and amino acids. Amino acid solutions taste unpleasant and are relatively expensive, so unless there is extensive impairment of gastrointestinal digestive and absorptive functions they appear to offer little additional benefit. Their use is increasing in a variety of situations in research institutions.

Disease specific feeds

Disease specific feeds generally play little part in long term enteral nutrition. They can be used in severely ill patients, such as those with multiple burns or trauma, respiratory failure, advanced cirrhosis, or acute renal failure. Renal specific diets can be useful in chronic renal failure.

ROUTES OF ACCESS

Oral

The oral route is the preferred method of administration. Interventional tube feeding (if medically appropriate) is required for patients unable to ingest adequate amounts of nutrition.

Tube feeding

Enteral tube feeding is a valuable treatment modality in the management of both acute and chronic illness. Recent advances in access devices, feeds, and pumps have made enteral feeding a viable option for many clinicians and their patients. Increasing pressure on hospital beds, the development of a homecare industry, and advances in technology have led to a 20%–25% annual increase in the number of patients receiving enteral tube feeding in the community in the UK.[10] Staff in healthcare settings need to be able to manage enteral tube feeding. Achieving and maintaining access to the gastrointestinal tract is a prerequisite for enteral feeding.

INDICATIONS AND CONTRAINDICATIONS FOR TUBE FEEDING

The majority of patients require nutritional support for around one month or less. If patients are unable to take supplemental sip feeds safely then enteral tube feeding is required. The different methods of enteral tube feeding are listed below. Enteral tube feeding can be used in a wide range of disease states. Table 1 lists common reasons for enteral feeding in adults in the UK. However, there are also a number of absolute and relative contraindications listed also.

Table 1 Indications and contraindications for enteral feeding

Indications	Relative contraindications
Medical	Intestinal obstruction
Inflammatory bowel disease	Ileus
Hepatic failure	High output small bowel fistula
Renal failure	High doses positive inotropic agents
Respiratory failure	
Neurological	Enteral feeding can be given in the presence of gut obstruction or when there is a high output small bowel enterocutaneous fistula
Cerebrovascular accident	
Motor neurone disease	
Acquired brain injury	
Brain tumour	
Parkinson's disease	
Surgical	
Preoperative	
Postoperative	
Fistula	
Burns	
Sepsis	
Head and neck cancer	
Gastrointestinal tract cancer	
Gastrointestinal tract surgery	
Pancreatitis	
Orthopaedic	
Trauma	
Psychiatric	
Anorexia nervosa	
Paediatric	
Cystic fibrosis	
Miscellaneous	
Intensive care patients	
Short bowel	
Cachexia	
Transition from parenteral nutrition	

NASOENTERIC FEEDING TUBES

Nasoenteric enteral tubes are preferred to oroenteral tubes, for reasons of practicality; nasoenteric tubes are easier to secure, and are less likely to be disturbed by eating. Allowing the introduction of oral feeding is a further advantage of nasoenteral feeding, and the nasal route makes for easier insertion.

Nasogastric tube feeding

The majority of patients requiring nutritional support will need it for less than one month, and nasogastric tube feeding is by far the most commonly used route of access. Fine bore nasogastric tubes have reduced the incidence of complications, such as rhinitis, oesophageal reflux and strictures and oesophagitis, that were associated with the large bore Ryle's tube.[11] Complications of tube feeding are listed in table 2, and are discussed later.

All tubes, whether nasogastric or percutaneous, can become clogged. This can be minimised by regular flushing with water and using liquid medication if it is required rather than crushed tablets.

Nasogastric tubes are fairly easy to insert, but should only be done by trained staff because of the risk of misplacement and oesophageal or pulmonary perforation.[12] It is particularly important that fine bore tubes with wire stylets should always be inserted by trained personnel, not only to minimise the risk of misplacing the tube, but because only trained personnel will be sufficiently experienced to recognise that this problem may have occurred.

Table 2 Complications of enteral nutrition

Mechanical	
	Unable to pass a tube
	Malposition (tube placement into the trachea, pneumothorax, intracranial placement)
	Unwanted removal
	Blockage
	Nasopharyngeal pain, erosions, sinusitis, otitis media
	Hoarseness, laryngeal ulceration
	Oesophageal erosions, oesophagitis, and strictures
	Tracheo-oesophageal fistula, variceal rupture
	Duodenal perforation
Gastrointestinal	
	Diarrhoea or constipation
	Bloating
	Abdominal distension
	Reflux
	Nausea
	Cramps
	Regurgitation
	Pulmonary aspiration
	Drug interactions
Metabolic/biochemical	
	Vitamin, mineral, trace element, essential fatty acid deficiencies
	Hyperglycaemia
	Hyperkalaemia
	Hypophosphataemia
	Hypomagnesaemia
	Hypozincaemia
	(most common)
Miscellaneous	
	Abnormal liver function tests
	Pulmonary aspiration
	Feed contamination and resulting infection

If the tube is inadvertently inserted into the trachea or bronchi, intrapulmonary aspiration of feed may occur with potentially fatal results. Methods for checking the position of the tube include air insufflation and auscultation of the epigastrium, and aspiration of gastric contents and testing with litmus paper. Ability to aspirate gastric contents is more successful with some makes of tubes than others, and may not be possible with some fine bore tubes. If aspiration or auscultation is unsuccessful or there is any doubt about tube position *x* ray confirmation is needed. Care should be taken when using the method of insufflating the tube with air and auscultating above the stomach for bubbles; in intensive care patients a feeding tube in the left lower lobe of the lung, particularly in pulmonary oedema, or pneumonia can bubble and mimic gastric placement.

Although nasogastric tubes have been used successfully for long term enteral nutrition, non-elective extubation, the risk of tube misplacement, and the occasional need to check the position of the tube by *x* ray do not make it the ideal long term method of tube feeding.

Nasoduodenal/nasojejunal tube feeding

Patients at high risk of pulmonary regurgitation, such as those with gastric atony or gastroparesis, and patients with pancreatitis, where it is considered desirable to feed beyond the ampulla, should be considered for a postpyloric tube,[13] but there is still a 2.4% risk of aspiration.[14]

Placing nasoenteral feeding tubes postpylorically can be difficult. Spontaneous transpyloric passage of standard feeding tubes after 24 hours is only in the order of 30% and does not seem to be affected by tip profile or addition of a weight to the tip of the feeding tube.[15]

Although previously the only satisfactory way to place such tubes was by endoscopy or fluoroscopy, there has been increasing interest in "self propelling" feeding tubes with a coiled end that enables the tube to be placed in the stomach "blind" and then is propelled via peristalsis to the jejunum.[15] Theoretically, because these tubes are anchored in the jejunum with the coil they have a reduced risk of displacement and therefore aspiration. We have used "self propelling" nasojejunal tubes for enteral feeding successfully for an number of patients with acute pancreatitis and hyperemesis gravidarum,[16] and we await the progress of further clinical experience. Fluoroscopic and endoscopic techniques can be used to place postpyloric feeding tubes with variable success, but are time consuming procedures.

Placing a tube postpylorically does not reduce the problem of inadvertent removal. Because of this, as well as cosmetic appearance and discomfort, other methods of providing long term nutrition have been developed.

ENTEROSTOMY TUBE FEEDING

As a result of some of the difficulties encountered with nasoenteric feeding tubes alternative routes of tube feeding have been developed. Some of these methods are particularly useful for long term feeding.

Tube enterostomies can be placed using surgical, endoscopic, or radiological methods into the gastrointestinal tract. Tube enterostomies can be either permanent or temporary, and are usually placed if it is likely that feeding of more than four weeks will be required, or if nasoenteral access is compromised in the short term.

Percutaneous endoscopic gastrostomy (PEG)

In 1980 Gauderer *et al* described inserting a percutaneous gastrostomy tube under local anaesthetic using endoscopy.[17] The PEG tube has rapidly become the method of choice for long term feeding.[18] It is safer and more cost effective than surgically placed gastrostomies, with a low procedure related mortality (2%) and complication rate.[18 19] There is less interruption from tube displacement compared with nasogastric feeding.[20] There may also be less reflux and feed aspiration, suggesting that overnight feeding is relatively safer.[21] This is important for mobile patients who do not want to be constrained during the day.[22]

Complications of PEGs, such as peristomal infection, peritonitis, tube blockage, inadvertent removal, tube fracture and leakage, can be minimised by having a home enteral nutrition team.[18 19] If a PEG is inadvertently removed, a Foley catheter can be inserted through the tract and feeding restarted until the PEG is replaced either endoscopically with a standard PEG tube or non-endoscopically with a button gastrostomy. For those at risk of oesophageal reflux, the PEG can be converted into a jejunostomy using a kit, although the risk is not completely eliminated.[23]

If the PEG tube is no longer required they can either be removed endoscopically or cut; the internal bumper can be allowed to pass internally.[24] Some of the newer PEG tubes are designed to be removed by collapsing an internal fixing balloon or by pulling the PEG through the opening in the abdominal wall.

Percutaneous endoscopic duodenostomy/jejunostomy
These have often been used for patients with unsuitable stomach access and patients at risk from aspiration pneumonia; however, insertion is technically more demanding than PEG tubes.[23]

Cervical pharyngostomy/oesophagostomy
These methods are most frequently used after head and neck surgery (they can be accessed by open surgery or by a percutaneous technique[25]), but are not widely used for long term feeding because of the ease and relative safety of inserting a PEG.

Surgical gastrostomy
Indicated for patients in whom PEG cannot be performed or as an adjunctive procedure at the time the patient is undergoing surgery. Indications include oesophageal atresia, stricture and cancer, dysphagia due to neuromuscular disorders, or after trauma. Relative contraindications include primary disease of the stomach, abnormal gastric or duodenal emptying, and significant oesophageal reflux. Specific complications include local irritation, haemorrhage, skin excoriation from leaking of gastric contents, and wound infection. Intraperitoneal leakage of gastric contents, wound dehiscence, and delayed stoma closure can cause peritonitis.

Surgical jejunostomy
There are three basic types of surgical jejunostomy in use: a Witzel jejunostomy, Roux-en-Y jejunostomy, and needle catheter jejunostomy. Witzel jejunostomy involves formation of a serosal tunnel and is preferred by some surgeons, but is more likely to become infected. Needle catheter jejunostomy is most frequently used, which involves inserting a needle obliquely through the mesenteric border of the jejunum; a Seldinger technique is used to subsequently insert the feeding tube through the abdominal wall. The external end of the feeding tube is then brought out through the anterior abdominal wall at a site distant from the laparotomy wound.[26]

Needle catheter jejunostomy is usually performed while the patient is undergoing major abdominal surgery, although it can be performed as a separate surgical procedure. These are useful for both long and short term enteral feeding and when feeding into the stomach is contraindicated, for example after oesophageal, gastric, pancreatic, or hepatobiliary surgery. Contraindications include local Crohn's disease, ascites and immunosuppression, and complications are in common with other surgical enterostomies.[26]

Fluoroscopic percutaneous gastrostomy
This compares favourably with PEG in morbidity and mortality and has been used for patients with ascites or peritoneal dialysis, which are relative contraindications to PEG insertion.[27] However, this technique is not widely available.

Nasogastric feeding tubes

- Nasogastric.
- Nasoduodenal/nasojejunal feeding tubes.

Enterostomy tube feeding

- Percutaneous endoscopic gastrostomy, duodenostomy, or jejunostomy.
- Fluoroscopically inserted percutaneous endoscopic gastrostomy.
- Open surgical, needle catheter, and laparoscopic jejunostomy.
- Surgical enterostomy.
- Cervical pharyngostomy/oesophagostomy.
- Surgical gastrostomy/jejunostomy.

PROBLEMS WITH ENTERAL TUBE FEEDING
There are a number of potential complications that can occur with enteral tube feeding, which can be divided into mechanical, gastrointestinal, metabolic/biochemical, and miscellaneous (table 2).

Complications of nasoenteric feeding tubes
The complications of nasoenteral feeding tubes are less common since the introduction of fine bore nasoenteral feeding tubes in the 1970s.[11 28] Fine bore tubes (usually with wire stiffeners) are easier to pass, more flexible and are less likely to cause erosions, oesophagitis, or strictures. Tube blockage, misplacement, and unwanted removal are still potential problems.

Tube blockage
Tube blockage can occur with crushed medication, inadequate flushing (particularly with nasojejunal tubes, which tend to be longer and of a finer bore), and with precipitation of protein in the feed.[29] Ideally tubes should be regularly flushed, every six hours in the case of nasojejunal tubes, and flushed before and after use. Tubes can generally be unblocked with water, although fizzy drinks, pancreatic enzymes, and commercial preparations (for example, Clog Zapper; Corpak MedSystems) have been tried with varying success.

Physical complications
Physical complications are related to the size, material and pliability of the tube, with polyurethane tubes being softer and so less traumatic than polyvinylchloride.[28 30]

Local complications are common, with discomfort when the tubes are passed, again being dependent largely on the diameter, softness of the tube, and type of tip.[31]

Nasopharyngeal discomfort due to the physical presence of the tube in the throat is common. There may be a deficiency in saliva production due to mouth breathing and no chewing. Sore mouth, dysphagia, sensation of thirst, and dry mucous membranes are recognised complications.

Intracranial insertion of tubes is a small, although documented, risk.[32] More pliable, soft tubes and more careful insertion may reduce this, although modern tubes with internal wires may increase the risk of this potentially fatal complication. It is well known, and included in all product literature that reinsertion of guidewires with feeding tubes in situ should not be attempted due to the risk of the wire passing either through an outflow port, or perforating the tube and then perforating the viscus.

Gastro-oesophageal reflux may occur more frequently when a nasoenteric tube is used in the supine position.[33] This may be in part due to lack of gravitational effect keeping gastric contents in the stomach, and exacerbated by the presence of the feeding tube impeding the effectiveness of the gastro-oesophageal sphincter, and larger bore tubes seem to affect the cardio-oesophageal junction most.[34] Whatever the diameter of tubes it is probably preferable not to feed patients lying flat. Prokinetics, sucralfate, or proton pump inhibitors could be used to treat oesophagitis.

Tracheo-oesophageal fistula may develop when large bore nasoenteric tubes are used with a nasotracheal or tracheostomy tube in place. The fistula develops from pressure necrosis of the oesophagus and trachea.

Endobronchial placement is most common in those with altered swallowing or a reduced gag reflex. Intrapulmonary infusion of enteral diet can be fatal if not recognised. Other complications which can arise from misplacement of tubes include pneumothorax,[12] intrapleural infusion of enteral diet,[35] and oesophageal perforation.[36] Patients most at risk from misplacement of tubes include those on ventilators, with altered level of consciousness or with neuromuscular abnormalities, such as reduced gag, swallow, and cough reflexes.[37] In this group of patients it is important to confirm the position of tubes radiologically, although other methods of checking tubes are detailed above.

Probably the most common complication, reported in up to 60% of patients, is non-elective.[38 39] For this reason district nurses or staff in long stay institutions should be trained in tube insertion, and special attention should be paid to their securing.

Securing enteral feeding tubes

It is important to secure feeding tubes. In our experience, in addition to the studies above, the incidence of accidental loss is high,[38 39] particularly with nasoenteral feed, and particularly in the critically ill who often have altered levels of consciousness, and are unable understandably to concentrate on keeping the tubes in.

Generally, the distance that tubes are inserted should be recorded, or even the tube itself marked with tape so migration can be identified. Most feeding tubes have markings imprinted onto the tubing.

When securing a tube, clean the skin with alcohol to remove surface oil; some skin protectants are available, which can be used before taping to the nose and cheek. Commercially available attachment devices are available which adhere to the nose, holding the tube in place with an adjustable clip, although we have no experience of these, and again local centres tend to have systems which work best in each situation. Generally the tube should be secured tightly enough to avoid dislodgement, but not enough to cause undue pressure on the nostrils, which can cause ulceration if used for prolonged periods. We have found "Steristrips" useful, although these must be frequently checked, and can be very tight if not correctly applied.

Similar advice should be given in securing enterostomy tubes, although these usually have internal anchoring devices, which makes dislodgement less likely. How tightly they are secured is often a matter of personal preference for the practitioner; again they should be firm enough to prevent possible dislodgement and leakage, but not so tight to cause possible tissue necrosis and ulceration. If tubes become dislodged completely, generally the tract closes spontaneously if the tube is not replaced, although each individual case tends to be different, and needs individual rather than generalised advice.

It is important to emphasise that patient, carer, and staff education is the key, and generally patients or their carers are the best people to ensure non-elective extubation does not occur. If patients are given clear information about the need for the tube, and given support whether or not problems occur, compliance will improve, and accidental complications will be less likely to occur, both in inpatients and patients in the community.

Complications of enterostomy tubes

There are a number of problems with surgical gastrostomies, although they have been around for many years. These include wound dehiscence, infection, leakage, aspiration, and bleeding. The morbidity and mortality rate varies from 3% to 61%[40] and up to 37% respectively.[18] The difference probably relates to the condition of the patient in whom the gastrostomy is performed. Patients are often elderly, malnourished and suffering from strokes, malignancy or head injury, and many surgical gastrostomies are performed under general anaesthetic adding further to the risk.

Endoscopic gastrostomy

PEGs are increasingly widely accepted, are easy and simple to insert, have a lower morbidity and mortality, generally do not need a general anaesthetic, and are cheaper than surgical gastrostomies.[21] Generally contraindications include occluding pharyngeal or oesophageal tumour, ascites, peritoneal dialysis, and coagulopathy.[21]

Complications include peristomal infection, leakage, accidental tube removal, tube blockage, tube fracture, tube displacement, peritonitis, aspiration pneumonia, bleeding, gastric mucosa overgrowth, and death.[18 21] Ultrasound may show a peristomal abscess, and "tubograms" may help if tube blockage and/or leakage is suspected, using sterile water soluble contrast. Smaller tubes seem to reduce the risk of infection and leakage from PEGs with no increased risk of tube blockage.[41] For patients particularly at risk from aspiration a PEG can be converted to a jejunostomy (PEGJ), although the risk is not completely eliminated.[42] PEGJs are not often used, as they are difficult to insert and commonly become dislodged back into the stomach, entailing the risks that were intended to be avoided by the use of jejunal feeding. As PEGJs are necessarily longer, and often of narrower diameter that PEG tubes, they are more prone to blocking in the same way as jejunal tubes.

Aspiration

Aspiration of feed can occur without obvious evidence of vomiting, particularly in those patients with poor mental status, and absent gag reflex. The regurgitation is usually silent until signs of respiratory compromise or pneumonia develop, which are generally not difficult to spot, with dyspnoea, cyanosis, tachycardia, hypotension and *x* ray changes, although these signs may well not be immediately attributed to feed aspiration in the community. Clinically significant aspiration occurs in up to 30% of patients with tracheostomies of translaryngeal intubation[43] and 6%–12% in neurological patients.[37] Patients particularly at risk are the old, debilitated, demented, those with impaired mental function, and those with disordered swallow function. Treatment includes stopping the feed, trying to aspirate feed from the lungs with suction, or antibiotics if infection is confirmed and signs continue.

The risk of aspiration may be reduced by elevating the head of the bed to around 30 degrees, and by using iso-osmotic feeds (as high osmolality feeds can significantly delay gastric emptying[44]). Postpyloric feeding does not necessarily reduce risk of aspiration as tubes often reflux back into the stomach. Promotility drugs may reduce the possibility of aspiration in patients most at risk.

Risk of aspiration may be reduced by continuous pump feeding. However, as aspiration risk seems to be greatest overnight, and continuous feeding means feeding over a 20–24 hour period, this may possibly increase the risk of aspiration.[45] Increasing the time off feeding overnight may reduce the risk of aspiration, particularly in patients without a gag reflex.

Metabolic and biochemical complications of enteral feeding

Metabolic problems include a deficiency or excess of electrolytes, vitamins, trace elements, and water.[46] Patients

Questions (true/false; answers at end of paper)

1. Malnutrition affects 40% of hospitalised patients.
2. Elemental feed is the most commonly used type of enteral feed.
3. The majority of patients who will require enteral nutrition will need it for one month or less.
4. Patients at high risk of aspiration should never be considered for nasoenteric tube feeding due to the high risk of complications.
5. Phosphate and potassium levels should be closely monitored when feeding malnourished patients due to the risk of refeeding syndrome.

receiving artificial support should be monitored closely as a result, and because of the risk of developing refeeding syndrome.[2]

Generally haematological and biochemical parameters should be measured before introducing nutritional support. Close monitoring is required particularly initially, and patients on long term enteral nutrition may require vitamin and trace element analysis if clinically indicated.

Common problems include overhydration, which may develop in up to 25% of tube fed patients and hypertonic dehydration in up to 10%.[47] Hyponatraemia is generally due to a dilutional state induced by excessive concomitant use of intravenous dextrose or water, while hypernatraemia is often due to free water loss, iatrogenic, due to excessive use of 0.9% saline solutions, or albumin, or more uncommonly an inability to conserve free water secondary due to transient diabetes insipidus.[47]

Refeeding syndrome

Refeeding malnourished patients increases basal metabolic rate, with glucose being the predominant energy source.[48] This anabolic response causes intracellular movement of minerals, and serum levels may fall significantly. These rapid changes in metabolism and electrolyte movement may lead to severe cardiorespiratory and neurological problems resulting in cardiac and respiratory failure, oedema, lethargy, confusion, coma, convulsions, and death.[48] The symptoms of the refeeding syndrome are thought to be due predominantly to hypophosphataemia, but metabolic changes in potassium, magnesium, glucose, and thiamine can also contribute.[48] Thiamine deficiency may contribute to refeeding syndrome, with Wernicke's encephalopathy being precipitated by carbohydrate administration. Patients at highest risk from the refeeding syndrome include those with chronic malnutrition, chronic alcoholics, and those on a prolonged fast or on intravenous hydration only.[49]

Gastrointestinal complications of enteral tube feeding

Complications directly related to the gastrointestinal tract are the most common complications of enteral tube feeding.[50] Nausea, possibly related to smell, osmolality, altered gastric emptying, and too rapid administration of feed is common. Abdominal bloating and cramps may also be due to delayed gastric emptying.[44]

Constipation is a common problem, and there is little conclusive evidence that lack of dietary fibre in enteral feed is the cause.[51] The lack of effect on constipation from fibre may be due in part to the manufacturing process altering the physicochemical properties of the added fibre.[52]

The commonest reported complication of enteral tube feeding is diarrhoea, which can occur in up to 30% of patients on general medical and surgical wards[53] and 68% of patients on intensive care units.[54] There is considerable variation, however, in the reported incidence of different investigators, probably in part due to the difference in definition of diarrhoea used. We generally define it as an increase in bowel frequency and/or fluid content of the stool compared with the normal bowel habit. A generally accepted scientific definition of diarrhoea is more than 250 g of stool per day. Diarrhoea is distressing for patients and their relatives, time consuming for nursing staff, and can add to potential problems such as infected pressure sores and altered fluid and electrolyte balance. If severe, diarrhoea may result in cessation of enteral feeding and institution of parenteral feeding with its attendant risks and costs.

Aetiology of enteral tube feeding related diarrhoea includes drugs and antibiotics,[55] in part due to the "inert carriers" for the active compound, such as sorbitol, in part due to alteration of intestinal flora by antibiotics, including *Clostridium difficile* and its toxin. Fat malabsorption, lactase deficiency, and contaminated feeds and feeding equipment may contribute.

Microbial contamination and infection of feed

Enteral feed provides an excellent growth medium for bacteria. A variety of organisms have in the past been cultured from enteral feed.[56] The risk starts as soon as the feed is opened, through a variety of routes, and involving handling type of delivery system, prolonged hanging time, and ascending spread of bacteria up the giving set.[56] Up to 36% of enteral feeds given by continuous drip have been found to be contaminated in some studies.[57]

Contaminated feeds have been reported to cause serious infections, particularly in susceptible individuals, such as the immunocompromised. Contamination can cause not just diarrhoea, probably the commonest manifestation, but also pneumonia and sepsis. Although oral or gastric feeding in a healthy individual rarely causes problems due to the antibacterial effects of saliva and gastric acid, contamination of nasoduodenal or jejunal feed which bypasses these mechanisms can result in serious morbidity. A similar effect can result in achlorhydria, either caused by drugs or pathology. There is some argument as a result in favour of the use of sterile feed.[58 59] At the very least, feed containers and giving sets should be changed every 24 hours, and some authors suggest a break between feeds to allow the gastric pH to fall.[56]

CONCLUSION

We believe that increasing interest in the subject of nutrition, both in health and in disease, will confer great benefit to both hospital patients and the general population. We hope that the above review is helpful, and would be interested in any comments; please send suggestions to the corresponding author.

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Key references

1. McWhirter JP, Pennington CR. Incidence and recognition of malnutrition in hospital. *BMJ* 1994;**308**:945–8.
2. Pennington CR. Artificial nutritional support for improved patient care. *Aliment Pharmacol Ther* 1995;**9**:471–81.
3. Reilly JJ, Hull SF, Albert N, *et al*. Economic impact of malnutrition: a model system for hospitalized patients. *J Parenter Enteral Nutr* 1988;**12**:371–6.
4. ASPEN Board of Directors. Special report: guidelines for the use of enteral nutrition in the adult patient. *J Parenter Enteral Nutr* 1987;**11**:435–9.
5. Payne-James JJ, Silk DBA. Enteral nutrition: background, indications and management. *Bailleres Clin Gastroenterol* 1988;**2**:815–47.

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REFERENCES

1 **McWhirter JP**, Pennington CR. Incidence and recognition of malnutrition in hospital. *BMJ* 1994;**308**:945–8.
2 **Pennington CR**. Artificial nutritional support for improved patient care. *Aliment Pharmacol Ther* 1995;**9**:471–81.
3 **Keys A**, Brozek J, Henschel A, *et al. The biology of human starvation.* Minneapolis: University of Minnesota Press, 1950.
4 **Hill GL**. Body composition research: implications for the practice of clinical nutrition. *J Parenter Enteral Nutr* 1992;**16**:197–218.
5 **Rana SK**, Bray J, Menzies-Gow N, *et al.* Short term benefits of post-operative oral dietary supplements in surgical patients. *Clin Nutr* 1992;**11**:337–44.
6 **Reilly JJ**, Hull SF, Albert N, *et al.* Economic impact of malnutrition: a model system for hospitalized patients. *J Parenter Enteral Nutr* 1988;**12**:371–6.
7 **Fiaccadori E**, Borghetti A. Pathophysiology of respiratory muscles in course of undernutrition. *Ann Ital Med Int* 1991;**6**:402–7.
8 **Windsor JA**, Hill GL. Risk factors for post-operative pneumonia: the importance of protein depletion. *Ann Surg* 1988;**208**:214.
9 **Duncan HD**, Walters E, Silk D. Assessing long-term enteral feeding. *International Journal of Gastroenterology* 1997;**2**:16–19.
10 **Elia M**. Trends in HETF. *Clinical Nutrition Update* 1998;**2**:5–7.
11 **Silk DBA**, Rees RG, Keohane PP, *et al.* Clinical efficacy and design changes of "fine bore" nasogastric feeding tubes: a seven-year experience involving 809 intubations in 403 patients. *J Parenter Enteral Nutr* 1987;**11**:378–83.
12 **Eldar S**, Meguid MM. Pneumothorax following attempted nasogastric intubation for nutritional support. *J Parenter Enteral Nutr* 1984;**8**:450–2.
13 **McWey RE**, Curry NS, Schabel SI, *et al.* Complications of nasoenteric feeding tubes. *Am J Surg* 1988;**155**:257.
14 **Gutierrez GD**, Balfe DM. Fluoroscopically guided nasoenteric feeding tube placement: results of a one-year study. *Radiology* 1991;**178**:759–62.
15 **Bengmark S**. Progress in perioperative enteral tube feeding. *Clin Nutr* 1998;**17**:300.
16 **Pearce CB**, Collett J, Goggin PM, *et al.* Enteral nutrition by nasojejunal tube in hyperemesis gravidarum. *Clin Nutr* 2001;**20**:461–4 .
17 **Gauderer MWL**, Ponsky JL, Izant RJ Jr. Gastrostomy without laparotomy: a percutaneous endoscopic technique. *J Pediatr Surg* 1980;**15**:872–5.
18 **Moran BJ**, Taylor MB, Johnson CD. Percutaneous endoscopic gastrostomy. *Br J Surg* 1990;**77**:858–62.
19 **Hull MA**, Rawlings J, Murray FE, *et al.* Audit of outcome of long-term enteral nutrition by percutaneous endoscopic gastrostomy. *Lancet* 1993;**341**:869–72.
20 **Wicks C**, Gimson A, Vlavianos P, *et al.* Assessment of the percutaneous endoscopic gastrostomy feeding tube as part of an integrated approach to enteral feeding. *Gut* 1992;**33**:613–16.
21 **Mellinger JD**, Ponsky JL. Percutaneous endoscopic gastrostomy: state of the art, 1998. *Endoscopy* 1998;**30**:126–32.
22 **Safadi BY**, Marks JM, Ponsky JL. Percutaneous endoscopic gastrostomy: an update. *Endoscopy* 1998;**30**:781–9.
23 **Tapia J**, Murguia R, Garcia G, *et al.* Jejunostomy: techniques, indications, and complications. *World J Surg* 1999;**23**:596–602.
24 **Pearce CB**, Goggin PM, Collett J, *et al.* The "cut and push" method of percutaneous endoscopic gastrostomy tube removal. *Clin Nutr* 2000;**19**:133–5.
25 **Gaggiotti G**, Orlandi P, Boccoli G, *et al.* A device to perform percutaneous cervical pharyngostomy (PCP) for enteral nutrition. *Clin Nutr* 1989;**8**:273–5.
26 **Duncan HD**, Silk DBA. Nutritional support. *Encyclopaedia of human nutrition*. London: Academic Press, 1988.
27 **Hicks ME**, Surrant RS, Picus D, *et al.* Fluoroscopically guided percutaneous gastrostomy and gastroenterostomy: analysis of 158 cases. *Am J Roentgenol* 1990;**154**:725–8.
28 **Keohane PP**, Atrill H, Jones BJM, *et al.* Limitations and drawbacks of fine-bore nasogastric feeding tubes. *Clin Nutr* 1983;**2**:85–6.
29 **Marcaud SP**, Perkins AM. Clogging of feeding tubes. *J Parenter Enteral Nutr* 1988;**12**:403–5.
30 **Rees RG**, Attrill H, Quinn D, *et al.* Improved design of nasogastric feeding tubes. *Clin Nutr* 1986;**5**:203–7.
31 **Silk DBA**, Bray MJ, Keele AM, *et al.* Clinical evaluation of a newly designed nasogastric enteral feeding tube. *Clin Nutr* 1996;**15**:285–90.
32 **Wyler AR**, Renolds AF. An intracranial complication of nasogastric intubation. *J Neurosurg* 1977;**47**:297–8.
33 **Nagler R**, Spiro SM. Persistent gastro-oesophageal reflux induced during prolonged gastric intubation. *N Engl J Med* 1963;**269**:495–500.
34 **Forlaw L**, Chernoff R, Guenter P. Enteral delivery systems. In: Rombeau JL, Caldwell MD, eds. *Clinical nutrition*. Philadelphia: Saunders, 1990: 175–6.
35 **James RH**. An unusual complication of passing a narrow bore nasogastric tube. *Anaesthesia* 1978;**33**:716–18.
36 **Iyer VS**, Reichel J. Perforation of the esophagus by a fine feeding tube. *N Y State J Med* 1984;**84**:63–4.
37 **Olivares L**, Segovia A, Revelta R. Tube feeding and lethal aspiration in neurological patients: a review of 720 autopsy cases. *Stroke* 1974;**5**:654–7.
38 **Keohane P**, Atrill H, Silk DBA. Clinical effectiveness of weighted and unweighted "fine-bore" nasogastric feeding tubes in enteral nutrition: a controlled clinical trial. *Journal of Clinical Nutrition and Gastroenterology* 1986;**1**:189–93.
39 **Payne-James JJ**, Silk DBA. Enteral nutrition: background, indications and management. *Bailleres Clin Gastroenterol* 1988;**2**:815–47.
40 **Jarnagin WR**, Duh QY, Mulvihill SJ, *et al.* The efficacy and limitiations of percutaneous endoscopc gastrostomy. *Arch Surg* 1992;**127**:261–4.
41 **Duncan HD**, Bray MJ, Kapadia SA, *et al.* Prospective randomized comparison of two different sized percutaneous endoscopically placed gastrostomy tubes. *Clin Nutr* 1996;**15**:317–20.
42 **DiSario JA**, Foutch PG, Sanowski RA. Poor results with percutaneous endoscopic jejunostomy. *Gastrointest Endosc* 1990;**36**:257–60.
43 **Winterbauer RH**, Duming RB, Barron E, *et al.* Aspirated nasogastric feeding solution detected by glucose strips. *Ann Intern Med* 1981;**95**:67–8.
44 **Bury KD**, Jambunathan G. Effects of elemental diets on gastric emptying and gastric secretion in man. *Am J Surg* 1974;**127**:59–66.
45 **Jacobs S**, Chang RWS, Lee B, *et al.* Continuous enteral feeding: a major cause of pneumonia among ventilated intensive care unit patients. *J Parenter Enteral Nutr* 1990;**14**:353–6.
46 **Woolfson AMJ**, Ricketts CR, Hardy SM, *et al.* Prolonged nasogastric tube feeding in critically ill and surgical patients. *Postgrad Med J* 1976;**52**:678.
47 **Vanlandingham S**, Simpson S, Daniel P, *et al.* Metabolic abnormalities in patients supported with enteral tube feeding. *J Parenter Enteral Nutr* 1981;**5**:322–4.
48 **Solomon S**, Kirby DF. The refeeding syndrome: a review. *J Parenter Enteral Nutr* 1990;**14**:90–7.
49 **Duncan HD**, Silk DB. Diagnosis and treatment of malnutrition. *J R Coll Physicians Lond* 1997;**31**:497–502.
50 **Payne-James J**, Silk DBA. Clinical nutrition support. *BMJ* 1990;**301**:1–2.
51 **Patel DH**, Grimble GK, Keohane P, *et al.* Do fibre containing enteral diets have an advantage over existing low residue diets? *Clin Nutr* 1985;**4**:67–71.
52 **Kapadia SA**, Raimundo A, Silk DBA. The effect of a fibre free and fibre supplemented polymeric enteral diet on normal human bowel function. *Clin Nutr* 1993;**12**:272–6.
53 **Cole SJ**., Duncan HD, Silk DB. Intestinal motility. *Current Opinion in Clinical Nutrition & Metabolic Care* 1998;**1**:415–17.
54 **Kelly TWJ**, Patrick MR, Hillman KM. Study of diarrhoea in critically ill patients. 1983;**11**:7–9. *Crit Care Med* 1983;**11**:7–9.
55 **Guenter PA**, Settle R, Perlmutter S, *et al.* Tube feeding related diarrhoea in acutely ill patients. *J Parenter Enteral Nutr* 1991;**5**:277–80.
56 **Payne-James J**, Rana SK, Bray MJ, *et al.* Retrograde bacterial contamination of enteral diet administration systems. *J Parenter Enteral Nutr* 1992;**16**:369–73.
57 **Schreiner RL**, Eitzen H, Gfell MA, *et al.* Environmental contamination of continuous drip feedings. *Pediatrics* 1979;**63**:232–7.
58 **Bodoky G**. Complications of enteral nutrition. In: Sobotka L, ed. *Basics in clinical nutrition*. Prague: Galen, 2000: 100–4.
59 **Anderton A**. *Microbial contamination of enteral feeds—what are the risks?* Trowbridge, Wilts: Nutritia Ltd, 2000.

ANSWERS

1: T; 2: F; 3: T; 4: F; 5: T.