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REVIEW

Tube feeding in children with chronic kidney disease: technical and practical issues

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Abstract This review discusses the indications for enteral feeding in children with chronic kidney disease, the types of feeding tubes that can be used, methods of insertion and their benefits and complications.

Keywords Nutrition · Nasogastric tube · Gastrostomy · Percutaneous · Open

Background

Although the direct administration of nutrition via a tube from the mouth into the stomach was first described in the 1700s, and gastrostomy in the early 1800s, it was not until the early 1900s that the development of such tubes for routine clinical use occurred. Reports of the successful use of nasogastric feeding in children with chronic kidney disease (CKD) began in the 1980s, and even these early studies demonstrated benefits to growth [1–3]. Nasogastric tubes are uncomfortable, and have complications that make them less than ideal for long-term enteral support. As a result, the current standard of care for children needing long-term nutrition is to place a feeding gastrostomy.

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When is enteral feeding necessary?

Enteral feeding is indicated when calorie or protein intake is insufficient to maintain growth, despite dietary manipulation and medication [4, 5]. The age at which children are particularly vulnerable to malnutrition is the first 6 months of life, when growth is more rapid than at any other time and, therefore, highly dependent on nutrition. Because the rate of growth is so high at this age, it is not uncommon for infants with severe CKD to lose >2 height standard deviation score (Ht SDS), which may have a lasting effect on their final height achievement [6, 7]. Decreasing height centile after the age of 1 month warrants early intervention, but enteral feeding can improve growth at all ages [4, 7]. Another very important indication for tube feeding is when struggling with oral intake in an anorexic child causes intolerable strains within the family.

Chronic kidney disease is characterized by a predisposition to anorexia and vomiting. Poor appetite may be due to abnormal taste sensation [8], the requirement for multiple medications, the preference for water in the polyuric child, and elevated circulating cytokines such as leptin, tumor necrosis factor (TNF)-α and interleukin (IL)-1 and -6, which act through the hypothalamus to affect appetite and satiety [9]. Vomiting may result from gastro-esophageal reflux (GER) and delayed gastric emptying in association with increased polypeptide hormones [10], and may be so profound that as much as one third of feed can be lost [4]. The young child with renal dysplasia frequently has an obligatory loss of salt and water whose replacement can only be provided by a tube [11].

Other factors that contribute to insufficient nutrition include episodes of fasting surrounding surgical procedures and episodes of sepsis, which may have an significant effect on growth, principally in the infant. Importantly, many children with severe CKD have associated co-morbidities that influence feeding and growth in their own right [7].

The child on dialysis has even more issues that affect their nutritional intake. Such children are likely to be on fluid restriction, the appetite may be affected by the presence of a full abdomen due to dwelling dialysate and constipation in patients on peritoneal dialysis (PD), and there may be considerable losses of protein in the dialysate.

The recent KDOQI (Kidney Disease Outcomes Quality Initiative) pediatric nutritional guidelines recommend early institution of enteral feeding [5]. Surprisingly, data from the International Pediatric Peritoneal Dialysis Network (www.pedpd.org), which represents over 900 children from 44 countries, show that although 38% are prescribed dietary supplements, only 8% have gastrostomies. In contrast, at Great Ormond Street Hospital, 67% are prescribed supplements and 44% have a gastrostomy.

What can be done before resorting to enteral feeding?

It is possible to increase the feed concentration to improve the oral nutritional intake in the child with poor urine output. This will decrease the feed volume, which may be an advantage in the child on fluid restriction, but may worsen vomiting and cause diarrhea. Medications such as prokinetic agents (domperidone), H2-receptor antagonists (ranitidine), proton pump inhibitors (lansoprazole), and 5HT3 receptor antagonists (ondansetron) may be of benefit. The use of dummies may help with the development of oromotor skills. As weaning starts, advice must be given to prevent the development of food-aversive behavior, such as avoidance of forced feeding, allowing messy play with food, and eating with the family at meal times. The stresses on the family of trying to feed an anorexic child cannot be over-estimated.

Types of feeding tubes

A nasogastric tube is acceptable for a short time, and is the method of choice in the infant weighing <4 kg. Nasogastric tubes do have some benefits: placement is simple and easily taught to families, and there is no risk of peritonitis in children on PD. However, they also have significant disadvantages: the trauma of frequent replacement is considerable, not just to the child, but to the family too; they may inhibit the development of oromotor skills causing subsequent problems with speech and swallowing; they result in an altered appearance, giving the obvious demonstration of a "sick child"; and very rarely, may result in esophageal or gastric perforation. However, probably their most troublesome complication is that of an increased risk of GER, vomiting and aspiration.

Gastroesophageal reflux disease (GERD) often clinically manifests in ESRD patients as frank vomiting. It is possible to advance the feeding tube beyond the stomach, either into the duodenum or jejunum, to try to reduce vomiting. However, transpyloric tubes are easily displaced and require interventional radiology for insertion and replacement, with frequent radiation exposure. Also, they cannot be used for bolus feeds: only continuous feeds should be given this way. In our units, therefore, we take a proactive approach and prefer to opt for Nissen fundoplication in the child with ongoing vomiting that is compromising growth. Nissen fundoplication is usually successful in reducing vomiting, although retching may occur. There is a small risk that reflux will persist so that very rarely a "redo" becomes necessary [12].

Most families prefer the placement of a gastrostomy (Fig. 1) to any type of tube that is inserted through the nose, principally because a gastrostomy is more socially acceptable as it is hidden under clothing. It is also not associated with the abnormal development of oromotor skills. Enteral feeding via any route is associated with decreased vomiting and improved appetite, nutrition and growth [4]. The tube has the additional benefit of its potential use in the administration of medications, and the large fluid volumes that may be prescribed post-transplant.

Methods of gastrostomy insertion

Insertion of a gastrostomy may be performed using one of four approaches: percutaneous endoscopic (PEG), percutaneous

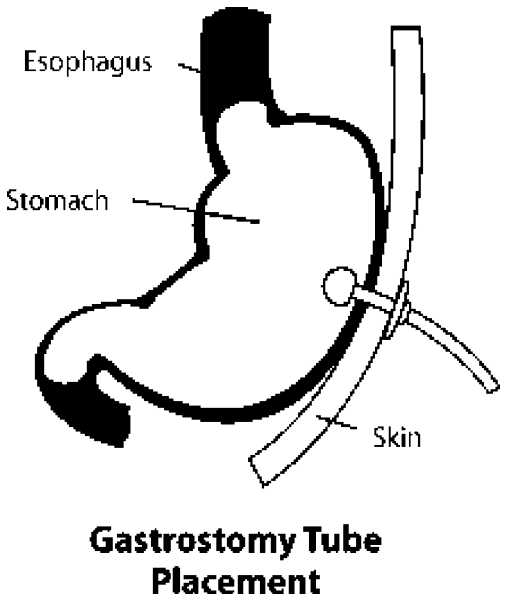

Fig. 1 The stomach and esophagus with a gastrostomy tube in situ

radiological, percutaneous laparoscopic, or "open", of which the commonest type is the Stamm [13]. Whatever the type of placement, the gastrostomy tube exit site is limited to the left upper quadrant (LUQ) of the abdomen or the midline because of the anatomy of the stomach. As a result, PD catheters should not be placed in the LUQ in children who may subsequently need gastrostomy placement.

Percutaneous gastrostomies

The PEG was first described in 1980 [14]. Because it is less invasive, it is preferred by most families to open surgery. However, there is an increased risk of injury to adjacent organs compared with open gastrostomy, a risk that must be considered seriously in children who are on, or will need, PD. Placement of a PEG is illustrated in Fig. 2. After insertion, the endoscopy is repeated to check that the placement is correct. This is known as the "pull technique".

The "push" technique is similar except that the wire is passed into the stomach, and used to pass dilators and then the gastrostomy tube.

Interventional radiological placement is similar to the push technique of endoscopic placement. Barium sulfate suspension is given the night before the procedure for colonic

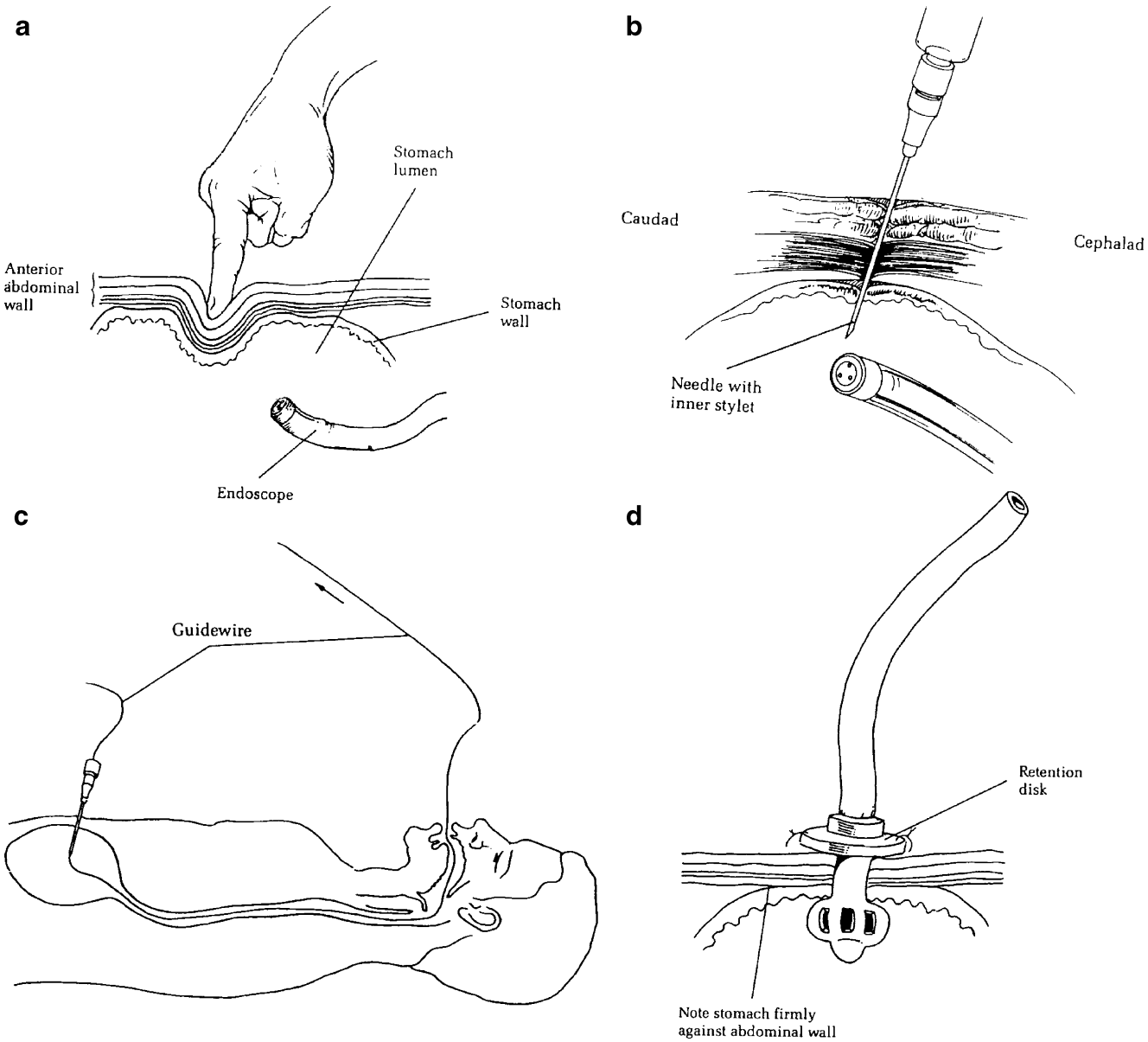

Fig. 2 Insertion of a percutaneous gastrostomy. **a** An endoscope is introduced into the stomach and the stomach is insufflated. **b** An intravenous catheter is inserted percutaneously and a wire is passed into the stomach. **c** The wire is grabbed and pulled out through the mouth and the wire is used to pull the gastrostomy tube from the mouth into the stomach and through the abdominal wall. **d** The percutaneous endoscopic gastrostomy is secured by rigid phalanges inside and outside the abdominal wall

opacification. A nasogastric tube is used to insufflate the stomach and screening is used to check that the bowel is satisfactorily displaced. The stomach bubble is identified on fluoroscopy or ultrasound and a needle is introduced and used to pass dilators for the gastrostomy tube.

Percutaneous laparoscopic procedures are similar to the push technique, but are done under direct vision using a laparoscope. It is difficult to combine with an endoscopic approach because of insufflation inside and outside the stomach.

It is important to note that, unlike an open gastrostomy, there are no sutures securing the gastric wall to the abdominal wall. The gastrostomy tube is held in place by a relatively rigid device, usually in the form of a "mushroom" tip. Although it is usually extremely limited, there will be a small amount of leakage of gastric contents during, and possibly after placement, until the stomach heals to the abdominal wall. Unlike the open gastrostomy, this takes place in the peritoneal cavity (the gastrotomy, or hole in the stomach, is made outside the peritoneal cavity during an open procedure). This leakage is sterile in virtually all patients and therefore, unless it is significant in quantity, should not be a problem. An important exception is patients on acid-reducing therapy (H2-receptor blockers or proton pump inhibitors). The use of these agents changes the pH of the stomach, and allows bacterial and fungal colonization. For this reason it is wise to cover all insertions and PEG changes with antibiotics [15] and, in some cases, antifungal agents as well. There is also a theoretical, but unproven benefit of stopping all acid-reducing agents in the week before surgery. Fungal prophylaxis is particularly indicated for children who have been on antibiotics prior to surgery [16].

Open gastrostomy (Stamm)

In the open technique, a small incision is made and the greater curvature of the stomach is pulled out of the peritoneal cavity for easy access. A purse string suture (or two) is placed in the stomach. A hole is made in the middle of the purse string and a tube (such as a Malecot or Pezzar catheter) or a button is placed through the purse string, which is then tied. The stomach is sewn onto the abdominal wall, usually with at least four separate sutures (Fig. 3). If a tube is used, it can be replaced by a button after 3–4 weeks. There are different types of button, e.g. the Mic-Key, Bard, or mini. The principle is the same—they all have a "stalk" to insert through the abdominal wall and something to hold the distal (intragastric) portion in the stomach. The internal fixation device can vary, although usually it is a water-filled balloon (Fig. 4). All buttons have a valve in the lumen to prevent leakage of stomach contents from the lumen of the tube. In the case of the Mic-Key, it is in the proximal part of the tube, near the skin. The Bard button has the valve in the

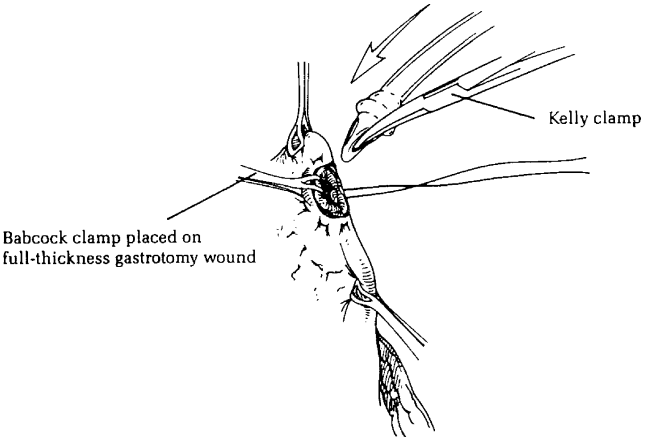

Fig. 3 An open gastrostomy

distal portion of the "stalk" of the button. The position of the valve is important because it determines the type of decompression tube to use if stomach deflation is needed. Gastrostomies are usually left unused, with the tube to gravity drainage, for 24–48 h before starting feeds. Complications are reported to be minor in 10–15%, major in 3–5%, and the mortality is up to 1% [11].

Complications of gastrostomies

1. Complications of all gastrostomies (regardless of method used) [11, 16–19]:
   a) Tube blockage
   b) Need for replacement. For balloon gastrostomy tubes or buttons this will be every 3–6 months. For the rigid PEGs or Bard buttons, replacement will be needed every 1–2 years. Unfortunately, this may mean a general anesthetic because of the rigid intragastric portion of the tube. Alternatively, some physicians cut this off and allow it to pass through the gastrointestinal (GI) tract.
   c) Balloon rupture. If the balloon has burst or is leaking, the button needs to be replaced. Parents can be taught to replace the button at home. A smaller lumen tube should be provided in case the button cannot be reinserted by the family. This should be inserted one inch into the gastrostomy and taped in place to keep the tract open until they get to the hospital.
   d) Tube displacement. If displacement occurs within 2 weeks of surgery, the tract will not be well formed, and forcing a tube may disrupt the stomach from the abdominal wall. The tube should, therefore, be replaced under radiological cover.
   e) Closure of the tract. This can happen very quickly or can take time. In general, the longer the feeding gastrostomy has been in place, the longer the time

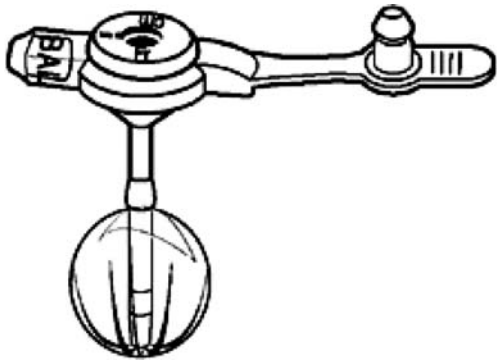

Fig. 4 A gastrostomy button

for the tract to spontaneously close. It is important, therefore, that parents are taught to come to the hospital straight away should there be problems.

f) Tract too large. The button can be taken out for progressively more hours to allow the tract to shrink.

g) Leakage around the gastrostomy exit site. This is almost universal. It is important not to do all the things that might seem logical, e.g. put in a bigger tube, pull the balloon tight to the abdominal wall or blow up the balloon more. The important thing is to wait for the tract to epithelialize, to keep the skin in good condition and cauterize any granulomas.

h) Skin irritation and itching. This is particularly likely to occur with severe leakage. The skin should be kept clean and dry, a barrier cream used and candida treated if necessary. Skin irritation may progress to "gastrostomy dermatitis". The skin should be cleansed each day with soap and water only, avoiding hydrogen peroxide, alcohol, betadine, and other lotions. Occlusive dressings should not be used.

i) Exit site infection may develop and requires the usual process of swabbing, topical antibiotic cream, and oral antibiotics if severe. Granulomas can be treated with application of silver nitrate twice a week.

j) Occasionally after removal of the gastrostomy tube the tract may not close spontaneously, resulting in a permanent gastrocutaneous fistula, which needs to be surgically closed.

k) Hemorrhage. Most commonly this is due to bleeding from granulation tissue, but can also be due to trauma, or rarely, gastro-intestinal bleeding. It is, therefore, important to differentiate bleeding through the lumen of the tube (GI bleeding) from bleeding around the tube (skin irritation or granulation tissue)

l) Exacerbation of GER due to distortion of the gastric anatomy. This may be counteracted by the use of a gastro-jejunal tube, entering via the gastrostomy site. Many of these patients may need a subsequent fundoplication.

2. Specific to PEGs:

   a) Intra-abdominal leakage (see above in the section "Percutaneous gastrostomies") and peritonitis (see the section "Timing of gastrostomy insertion in the child who is about to start or is on PD" below)

   b) Gastrocolic fistula, due to accidental snaring of the colon between the stomach and abdominal wall. The child may present with stools that look like the feed and weight loss.

Timing of gastrostomy insertion in the child who is about to start or is on PD

If it is at all possible, it is better to make a gastrostomy prior to commencement of PD in order to decrease the risks of peritonitis. This is because, as can easily be imagined, the placement of a tube percutaneously inevitably leads to a small leak of stomach contents into the peritoneal cavity. Dialysate, because of its high dextrose content, will encourage any organisms to rapidly multiply and result in peritonitis. There are no conclusive data, but based on the available experience, it seems logical that an open procedure would be preferable in children already on dialysis. The open procedure theoretically limits contamination of the peritoneal cavity by entering the gastric lumen outside the abdomen and by securing the stomach to the abdominal wall with sutures, rather than relying on a phalange to pull the stomach wall against the abdominal wall as in the percutaneous procedure. There is evidence demonstrating a greater risk of infection in children already on PD undergoing PEG: 10 out of 27 children (37%) in a multicenter German study developed peritonitis within 7 days of the procedure, and 7 (26%) developed fungal peritonitis. Four needed to switch to hemodialysis (HD) and there were two associated deaths [20]. On the other hand, at Great Ormond Street Hospital, although 4 out of 5 children given a PEG on PD developed peritonitis, there was no increased incidence in the 9 children who had an open procedure [21]. There is no evidence that there is an increased risk of peritonitis in children on PD with an established gastrostomy [5].

Outlook for termination of enteral feeding post-transplant

It is, in our experience, rare for appetite to recover such that enteral feeding can be stopped pre-transplant. However, post-transplant prospects are good. In the majority of

children, appetite improves post-transplant so that the gastrostomy can be removed: of 69 children post-transplant the gastrostomy was successfully removed in 80%, although some continued to need it for fluids and medications. The longest transition to normal feeding was 4 years [22]. In another report of 16 children, all successfully transitioned to oral feeding within 10 months, unless there was co-morbidity [23].

Continuing gastrostomy use will also be affected by the success of the transplant. The best way forward is to assess the dietary intake 4–6 weeks post-transplant, to proportionately decrease the feed as the oral intake increases, and to remove the gastrostomy when the diet, growth, fluids, and medication intake is satisfactory, provided that the transplant is functioning well.

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