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Advances and challenges of gastrostomy insertion in children

Bitar R *et al.* Gastrostomies in children

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Abstract

When oral feeding cannot provide adequate nutritional support to children, enteral tube feeding becomes a necessity. The overall aim is to ultimately promote appropriate growth, improve the quality of life for the patient and increase carer's satisfaction. Nasogastric tube feeding is considered appropriate for the support of fluid and nutrition in children on a short-term basis, however in the long term has many limitations and carries a reduced survival rate^[1]. Alternatively, gastrostomy feeding offers a more convenient and safer feeding option especially that it does not require frequent replacements, and carries lower risk of complications. Gastrostomy tube feeding should be considered when nasogastric tube feeding is required for more than 2-3 wk as per the ESPEN guidelines on artificial enteral nutrition^[2]. ESPGHAN recommendation on gastrostomy insertion in children recommends consideration of gastrostomy insertion when enteral feeding is required for more than 3-6 wk^[3]. Several techniques can be used to insert gastrostomies in children including endoscopic, image guided and surgical gastrostomy insertion whether open or laparoscopic. Each technique has its own advantages and disadvantages. The timing of gastrostomy insertion, device choice and method of insertion is dependent on the local expertise, patient requirements and family preference, and should be individualized with a multidisciplinary team approach (MDT)^[3]. We aim to review gastrostomy insertion in children including indications, contraindications, history of gastrostomy, insertion techniques and complications.

Key Words: Laparoscopic ⁸gastrostomy; Percutaneous endoscopic gastrostomy; Laparoscopic assisted gastrostomy; Laparoscopic-assisted percutaneous endoscopic gastrostomy; Radiologic gastrostomy; Open gastrostomy

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Core Tip: Gastrostomy tubes are inserted to support the long-term nutritional needs of children when oral feeding becomes compromised. Gastrostomy insertion has evolved over the last century to involve multiple feeding devices and various insertion techniques. The insertion technique and device choice need to be selected after careful consideration of patient background medical history, patient needs, facilities available and after adequate counseling in a multi-disciplinary team setting. In this review we will present the indications, contraindications, history, advances, insertion techniques, challenges and complications of gastrostomy insertion in children.

INTRODUCTION

When oral feeding becomes compromised, gastrostomy tubes (GTs) are inserted with an aim to support the long-term nutritional needs of children. Gastrostomy insertion has evolved over the last century to involve multiple feeding devices and various insertion techniques. The device chosen and the insertion technique are selected after careful consideration of patient background medical history, patient and family needs, facilities available. Prior to insertion, adequate counselling of parents and a multi-disciplinary team review is recommended. We aim to present the indications, contraindications, history, advances, insertion techniques, challenges and complications of gastrostomy insertion in children.

INDICATIONS AND CONTRAINDICATIONS

Indications

Gastrostomies should be considered when enteral feeding is required for more than 2-3 wk^[2] with an aim to correct significant nutritional deficiencies, promote growth in children, and avoid further body weight loss. Weight per age should be interpreted using disease-specific growth chart centiles when available. Gastrostomies are generally considered in children with underlying chronic nutritional needs such as patients with; oncological, metabolic, renal, neurological and gastrointestinal tract disorders in which oral intake is insufficient to sustain growth.

While the specific indications for gastrostomy placement are many and variable, the most frequent indications are related to inadequate oral fluid and nutrition intake and/or impaired swallow in disorders of the central nervous system, either as a primary cause or in conjunction with chromosomal or metabolic disorders. In addition, renal disorders, congenital cardiac disease, oncological disorders, chronic respiratory diseases such as cystic fibrosis, and gastrointestinal disorders such as Crohn's disease and intestinal failure may require gastrostomy feeding to correct nutritional deficiencies. Gastrostomies are also inserted in congenital or acquired conditions such as esophageal atresia and craniofacial surgery, when oral intake may be anatomically impeded. Moreover, they may be necessary in children who require nutritional restitution to attain recommended weights advisable for certain surgical interventions, like in infants with congenital cardiac disorders^[4,5]. Gastrostomies are also sometimes indicated in children with unsafe swallow, at risk of recurrent aspiration from oral feeding and when gastric drainage and decompression is required in cases of foregut dysmotility. Another rare but recognised indication is to deliver therapeutic formulae in patients with certain metabolic disorders, which are usually unpalatable. Finally, it can be offered to patients who require many medications due to other organ diseases to improve compliance and effectiveness of medications^[6-8].

Contraindications

Contraindications are relative and can typically be overcome. They include; lack of a safe tract for percutaneous insertion due to adhesions, congenital anomalies, severe

kyphoscoliosis, distorted anatomy due to multiple abdominal surgery, and interposed organs (liver, colon). In this case the surgical gastrostomy may be the only option whether it is laparoscopic or open. Significant coagulation disorders should be corrected, and placement should be deferred until full recovery if the patients suffer from hemodynamic instability, sepsis, significant ascites, infectious peritonitis, and abdominal wall infection at the placement site. Gastrostomy insertion in patients undergoing peritoneal dialysis is high risk and may be considered a relative contraindications by some centers^[9].

HISTORY AND ADVANCES

The initial use of enteral nutrition in the elementary tract to nourish patients date back to 1500 BC^[10]. Over the centuries, research has evolved and contributed to better understanding of; nutritional needs, methods to access the gastrointestinal tract, development of new tubes and equipment, with better understanding of digestion, absorption, and use of macro- and micronutrients.

The very first gastrostomy was used with a purpose of alimentation in obstruction at the gastric cardia or above in adults. It was proposed initially by Egeberg in 1837, and after multiple attempts and failures, it was not performed successfully until 1876 by Verneuil^[11]. At that time gastrostomies were inserted by conventional open surgery^[12]. In pediatrics, the procedure has been a mainstay of the early staged treatment of esophageal atresia; the first survivors of this condition were reported by Leven^[13] and Ladd^[14] in the early 1940's, and gastrostomy insertion was part of the therapy. Reports of Martin and Fultz^[17] in 1959, Holder and Gross^[16] in 1960, Meeker and Snyder^[17] in 1963, and others widened the popularity and indications for gastrostomy to include many pediatric surgical conditions. The less invasive percutaneous endoscopic gastrostomy (PEG) tube placement was introduced in 1980 by Gauderer *et al*^[18]. Glow in the stomach of a new born infant undergoing endoscopy inspired the development of this procedure. The first PEG was inserted in pediatric operating room on June 12, 1979 in the University Hospital of Cleveland, United States, on a four month old with

inadequate oral intake^[19] under local anesthesia with sedation. Although PEG was originally described in children, it has become a popular method of enteral nutrition in all ages. In 2001, 20 years after it was invented, over 216000 were performed annually in the United States^[20].

The application of gastrostomy later extended to cover non-surgical indications, such as supporting the nutritional requirements of patient with severe neurologic impairments and developmental delay. Because these two patient groups had a higher risk for general anesthesia, the open operation solely to place a gastrostomy promptly changed to the less invasive approach, the PEG. It was among the first innovations that expanded endoscopy from a diagnostic tool to a therapeutic instrument. It was not until 1991 when the laparoscopic gastrostomy application was first cited in the literature^[21]. It had the advantage of direct visualization of the peritoneal cavity during placement to protect from inadvertent bowel injury and optimize gastrostomy location while being less invasive than open gastrostomy. Although PEG and laparoscopic assisted gastrostomy (LAG) are the 2 most frequently used procedures for gastrostomy placement. To date, there is no agreement as to which procedure, is superior. Many centers prefer to insert a PEG owing to its simplicity and low costs^[22]. PEG has since become widely accepted in both the adult and pediatric populations.

Once the concept of minimally invasive procedure for gastrostomy was introduced, further modifications were introduced to reduce complication rates and facilitate the operative technique. Techniques such as the push gastrostomy technique has the advantage of avoiding the step of pulling the GT through the oropharynx and esophagus and preventing the carriage of microorganisms to the peristomal site^[4]. Although the push technique is associated with a lower peristomal infection rate than the pull technique in adults^[23] this has not been demonstrated in pediatric patients^[24,25]. Another technique modification to avoid the need for frequent general anesthesia with its associated risks, was the one-step gastrostomy device. The one-step gastrostomy device was an appealing, low-profile gastrostomy introduced in paediatric patients which uses a balloon device^[26]. The one-step gastrostomy is being increasingly used.

Because the balloon device does not offer the as ⁶secure fixation of the stomach to the abdominal wall as an internal bumper, gastropexy was introduced so that the stomach is ⁶fixed to the abdominal wall by sutures or T-fasteners^[27], as demonstrated in Figure 1. ⁴Gastropexy is performed to ensure adequate apposition of the stomach and the anterior abdominal wall^[26,28]. ³The one-step PEG/LAG placement with the push technique and T-fastener gastropexy^[24] gained popularity with its unique advantages. ³Regardless of technique of tube insertion, the GTs are generally changed to a low-profile button after ⁶6 wk to ⁸8 wk to allow for tract maturation^[29]. Recently more and more centers started to insert primary gastrostomy button feeding tubes.

A new technique, combining the use of endoscopy and laparoscopy in gastrostomy insertion was described in 1995 by Stringel *et al*^[30], the laparoscopic assisted PEG (LAPEG) was performed on 2 children where attempts at simple PEG had failed, this technique was used particularly in difficult cases where PEG was felt to be high risk or impossible. LAPEG combines both endoscopy and laparoscopy for gastrostomy insertion, while using a single umbilical incision to insert the laparoscope to assist in the gastrostomy placement. ⁷Using the laparoscope permits accuracy in the placement of the PEG, ⁷allows identification and subsequent lysis of adhesions, and safe completion of the PEG. In some centers LAPEG is performed routinely^[31], in others it is used when PEG is felt to be unsafe or impossible, in other centers it is used ⁷if the abdominal wall is > 2 cm, making it technically difficult to perform a laparoscopic gastrostomy^[32].

GASTROSTOMY INSERTION OPERATIVE TECHNIQUE

Parents should be given detailed information on the benefits, principles and decision making behind the choice of technique of gastrostomy insertion by the professional undertaking the procedure. Table 1 demonstrates the characteristics of different gastrostomy placement techniques. After MDT involvement, alternative methods of gastrostomy insertion should also be discussed including the pros and cons of each. Procedural as well as intermediate and long-term risks of the GT insertion are to be discussed with the parents/carers well in advance of the procedure to enable adequate

time to process the information, consider any questions and make an effective well-informed decision before giving consent. Regardless of the technique, at the time of gastrostomy insertion, it is recommended that patients are given antibiotic preoperatively^[33-35]. Most centers will allow immediate use of GT for medications, commencement of feeds may be variable depending on institutional consensus and is no later than one postoperative day.

Open gastrostomy

Open gastrostomy has been in use since more than 100 years and has remained the standard until the introduction of the less invasive insertion techniques. Nowadays, open gastrostomy is reserved for cases where the anatomy does not allow for a safe LAG or PEG insertion or the child cannot tolerate the pneumoperitoneum; as in cases of scar tissue formation from previous surgery. It should also be considered if the patient requires undergoing other surgical procedures at the same time.

There are different techniques described for open gastrostomy tube insertion, the most common technique used includes an incision made in the upper abdomen either midline or left subcostal and the abdominal cavity entered. ⁵ The stomach is identified, and an appropriate location for GT insertion selected, on the anterior wall of the body of the stomach, an opening is made on the stomach. The GT is passed through the abdominal wall ideally with the rectus sheath away from the umbilicus and costal margin and then inserted into the stomach. The tube is secured to the stomach with purse string sutures placed around the tube. ¹⁶ The stomach is then anchored to the abdominal wall from the inside with sutures. Finally, the surgical incision is closed with sutures.

PEG, pull through technique

Under endoscopic guidance, the stomach is inflated and a position for gastrostomy insertion on the anterior abdominal wall is identified using transabdominal impulse/finger indentation and transillumination. The abdominal wall and skin are

injected with local anesthesia. A puncture cannula is inserted through the anterior abdominal wall into the stomach cavity under endoscopic control while the stomach is inflated to allow opposition of the stomach wall to the abdominal wall. The needle is removed from the cannula and an introducer device containing a double thread is inserted through the cannula. The thread is pushed through the cannula until it is visible endoscopically in the stomach cavity. The thread is then caught and secured through the endoscope with a forceps or snare. The endoscope with the biopsy forceps/snare and adherent thread are pulled out through the mouth as one unit. The thread is then interlocked with the PEG, the PEG is lubricated with lubricant jelly, and the guide thread outside the abdominal wall is pulled through the cannula while the PEG is pulled through the mouth, esophagus and into the stomach. The PEG tube is pulled through the abdominal wall with the inner disk fitting snug along the gastric mucosa. Finally, the PEG is fixed to the anterior abdominal wall by adjusting the external bumpers that are provided with the gastrostomy device that is used.

Percutaneous image guided gastrostomy

The GT is inserted into the stomach by using the Seldinger technique. Nasogastric tube is placed shortly before the procedure to allow air insufflation. Gastric puncture is performed under fluoroscopic guidance with 18G puncture needle in left upper abdominal quadrant. To confirm insertion of the needle through the stomach lumen, the radiologist will aspirate air into a syringe or flushes the needle with contrast media, the gastric and abdominal wall are securely fastened together (gastropexy). Gastropexy is usually done using introducer needles preloaded with anchors. The abdominal wall and gastric walls are approximated, the gastric wall and stomach wall are punctured near the anchors. The tract is dilated using serial dilators, after adequate dilatation, a balloon type gastrostomy is pushed into the gastric lumen through peel away sheath. The retention balloon is inflated with water, and the procedure is completed with contrast injection through the GT to confirm correct tube position and to exclude extravasation or other complications.

LAG

Multiple modifications have been described to laparoscopic gastrostomy. In general, the procedure starts with insufflation of the peritoneum. Pressures are maintained between 6 to 12 mmHg based on patient comorbidities and size. A 5-mm telescope is placed through an umbilical port. An extra 5-mm port site is placed in the left upper quadrant below the costal margin. The stomach is then visualized and grasped along the greater curvature.

This small portion of the stomach can be delivered through the abdominal wall, at that time the port is removed and sutures are placed between the stomach and the abdominal wall. A small opening is made in the stomach and the tube is placed into the stomach.

Another technique to perform LAP gastrostomy is to fix the stomach to the abdominal wall by T fasteners or stitches then access the stomach by a needle followed by introduction of a guidewire through the needle. In that case the GT is inserted using the seldinger technique; serial dilatation of the tract is performed using dilators, after adequate dilatation of the tract, a balloon type gastrostomy is pushed into the gastric lumen through peel away sheath. Finally, the tube position is checked by infusing and aspirating saline solution under laparoscopic control.

Push one-step PEG

Under endoscopic control gastropexy is performed using 3 fasteners. At the center of the gastropexy a puncture site is identified and a trocar is inserted into the gastric lumen under direct visualization by the endoscopist. A guidewire is passed through the trocar which is later used to pass a dilator. After serial dilatation of the future gastrostomy track, a feeding tube is inserted into the stomach and the dilator is peeled away. The balloon is inflated

LAPEG

The procedure required both endoscopic and laparoscopic techniques, and therefore, both an endoscopist, and pediatric surgeon are required.

A 5-mm optical is placed through the umbilicus for the laparoscope. Pneumoperitoneum is recommended at 8-12 mmHg. At the same time a gastroscopy is performed and the stomach lumen is visualized. After insufflating the stomach, the optimal site for gastrostomy is chosen using external finger indentation and direct visualization. Gastropexy is performed using 3 fasteners, and a needle is inserted into the gastric lumen, a guidewire is passed through the needle which is later used to guide the dilator. After serial dilatation of the track, the GT is inserted and the balloon inflated and the tube is fixed to the skin at an appropriate length. Gastrostomy is inserted under direct laparoscopic and endoscopic visualization.

COMPLICATIONS AND CHALLENGES

GT insertion carries a procedural risk and is also associated with intermediate and long-term post operative complications. Complications, can be classified as minor or major. Major complications involve failure of GT placement, gastrostomy peritoneal leak causing peritonitis, tube dislodgement, buried bumper syndrome, adjacent bowel injury, major bleeding, oesophageal tear, and gastrocolic fistula formation. Minor complications, on the other hand, includes minor skin infection, granulation tissue formation, tube leak, and tube occlusion. There is also the possibility of development or aggravation of gastroesophageal reflux disease^[8]. One large meta-analysis looked at complication rates and mortality in association with different gastrostomy insertion operative techniques in children, data from 18 articles with 4631 patients were analyzed. Techniques compared were that of PEG (pull, single stage, or introducer, percutaneous image guided gastrostomy) and LAG insertion. The overall complications encountered were; minor (33% of patients)-granulation (10.30%), local infection (8.30%) and leakage (6.00%), major (10.00% of patients)-systemic infection (3.50%), cellulitis (1.00%) and perforation (< 0.30%) and lethal (0.15%). Interestingly, prematurity or young age did not affect complication rate^[4].

Laparoscopic techniques have been reported to be safer than endoscopic gastrostomy insertion procedures. In a retrospective comparative study between PEG, LAG and open gastrostomy including 236 children; the overall rates of major complication were 9.2% in the endoscopic gastrostomy, 8.9% in the laparoscopic, and 8.1% in open gastrostomy groups^[36]. In a larger meta-analysis, which included 8 studies and 1550 pediatric patients; LAG technique was found to be associated with only 1% chance of major complications compared to 5.4% in the PEG technique^[37]. Laparoscopic gastrostomy has unique advantages, the surgeon has a better visual intraperitoneal field thereby lowering the risk of perforation of hollow viscous and vascular injury, and particularly the formation of gastrocolic fistula which has been reported in children following PEG. A study examining endoscopic gastrostomy placement in infants less than one year of age found that despite successful placement in a healthier cohort, PEG had more morbid and more costly complications, specifically a 3.8% risk of gastrocolic fistula, compared to laparoscopic gastrostomy^[38]. Interestingly, in a systemic review, 8.4% (2.1%-19.4%) of children who underwent PEG and 2.5% (0.0%-8.6%) of children who underwent LAG required reintervention under general anaesthesia with a reported significant difference^[39].

Considering the various techniques used to insert GT tubes in children, the magnitude of the challenges faced with the procedure and the likelihood of complications is highly dependent on the technique used in GT insertion. The higher the blinded components of the technique the more likely are the challenges and major complications. The more of the directly visualised components of the technique the less likely are the challenges and major complications. Fixation of the stomach to the abdominal wall is another factor that reduces the likelihood of major complications, it reduces the occurrence of tube dislodgement and possible subsequent intraperitoneal leak. Gastropexy is feasible during laparoscopic, radiologic and push one step endoscopic gastrostomy^[26,28]. Based on the above principles, LAPEG in children is associated with a high safety profile because of direct endoscopic and laparoscopic visualization of the entire GT insertion process. A retrospective review of 76 paediatric

patients, LAPEG was performed and completed safely with no recognizable peri-operative complications, despite 26% of the cohort being considered as high risk with significant pre-existing comorbidities. The safety and use of LAPEG has also been supported by previous reports^[40-48]. A retrospective review comparing LAPEG to LAG demonstrated both procedures to be comparable in reduced major complication rate but with the added advantage of significantly shorter procedure time in the LAPEG group^[48]. In the past, 10 kg of weight was considered the lower limit of body weight for insertion of PEG tubes, below which the procedure was deemed to be more technically challenging^[49]. However, PEG insertion is reported to be safe in infants with weight as low as 2.3 kg^[50]. Minar *et al*^[51] described successful PEG in 39/40 infants with mean weight of 3.25 kg at the time of procedure. The only major complication reported was esophageal injury. There exists the hypothesis from scholar peers that younger children may be at higher risk of complications at time of PEG placement because they have thinner tissues which may be easier to transilluminate the gastrocolic omentum or the transverse colon. Thus, resulting in accidental penetration and traversing of the colon, and resultant gastrocolic fistula which can go undetected. Hence the recommendation by some in using the laparoscopic technique or the LAPEG technique in small patients^[52]. In the LAPEG report of 76 patients, one third of the patients were < 7 kg in weight and one third were < 7 mo of age. Therefore, LAPEG is a potential option for this subset of patients.

CONCLUSION

Although gastrostomy insertion has become a common procedure in children, the best method of placement still needs to be determined. The method of placement can vary significantly according to patient age, local expertise, and healthcare service available^[53]. Therefore, there is still much more research that needs to be considered including the best insertion technique for individual patient groups, the timing and type of best enteral feeds to be initiated after placement, and identifying specific risk factors for the development of complications. In our current climate of health

economics, reduction in the cost and local availability of resources required for gastrostomy placement in children should be considered. The ideal gastrostomy procedure is a one-step procedure, performed under minimal anesthesia, with no complications, at reduced cost and optimal resources utilization as long as patient safety is considered first and foremost. As technology enhances more advanced minimally invasive robotic surgical procedures are likely to expand. This can only succeed if we continue to challenge and improve our current practice by continued collaboration between pediatric surgeons and gastroenterologists with more multi-center good quality research of novel practice and modifications of gastrostomy techniques and perioperative management.

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Footnotes

Conflict-of-interest statement: There is no conflict of interest to declare.

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Figure Legends

Figure 1 Gastropexy of the stomach to the abdominal wall using three trans-gastric tuckers.

Table 1 Characteristics of different gastrostomy placement techniques

Parameters compared		PEG	PEG push technique	PIG	LAG	LAPEG	Open Gastrostomy
Operation under general anaesthesia	Yes	(occasionally under sedation)	Yes	No	Yes	Yes	Yes
Blind puncture through the abdominal cavity	Yes	Yes	Yes	No	No	No	No
Gastropexy	No	Yes	Yes	Yes	Yes	Yes	Yes
Pneumoperitoneum	No	No	No	Yes	Yes	No	No
Invasiveness, number of transabdominal wall wounds	1	1	1	3	2	Incision, midline or subcoastal	
Cosmetics; number of scars on abdominal wall	0	0	0	2	1	1 (incision)	
Repeat general anaesthesia/sedation for tube change	Yes	No	No	No	No	No	No

PEG: Percutaneous endoscopic gastrostomy; LAG: Laparoscopic assisted gastrostomy; LAPEG: Laparoscopic assisted percutaneous endoscopic gastrostomy; PIG:

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