Endoscopic gastrojejunostomy in infants and children.

Sophie Elmehdi, Delphine Ley, Madeleine Aumar, Stéphanie Coopman, Dominique Guimber, Audrey Nicolas, Matthieu Antoine, Dominique Turck, Maéva Kyheng, Fréderic Gottrand

Version of Record: https://www.sciencedirect.com/science/article/pii/S0022347622000701
Manuscript_3f933c83e5d498d9b99919dfaccd357e

Endoscopic gastrojejunostomy in infants and children

Sophia Elmehdi[1], Delphine Ley[1,2], Madeleine Aumar[1,2], Stéphanie Coopman[1], Dominique Guimber[1], Audrey Nicolas[1], Matthieu Antoine[1], Dominique Turck[1,2], Maeva Kyheng[3], Frédéric Gottrand[1,2]

[1]Division of Hepatology, Gastroenterology and Nutrition, and Reference Centre for Congenital and Malformative Esophageal Disorders, Department of Paediatrics, Univ. Lille, CHU Lille, Lille, France

[2]Univ. Lille, Inserm, CHU Lille, U1286 - INFINITE - Institute for Translational Research in Inflammation, F-59000 Lille, France

[3] Univ. Lille, Division of Methology, Biostatistic and Data Management, CHU Lille, F-59000 Lille, France

Corresponding Author:

Dr Sophia Elmehdi

Division of Hepatology, Gastroenterology and Nutrition, and Reference Centre for Congenital and Malformative Esophageal Disorders, Department of Paediatrics, University of Lille, France

elmehdi-s@ch-valenciennes.fr

The authors declare no conflicts of interest.

Portions of this study were presented as a poster during the ESPGHAN congress, June 5-8, 2019, Glasgow, Scotland.

Objective To evaluate the feasibility of endoscopic gastrojejunal tube (GJT) placement in infants and children.

Study design All children undergoing endoscopic GJT placement between January 2010 and December 2019 were included in this single-center retrospective study. Difficulties and failure of placement of GJT, complication rate, device longevity, as well as efficacy and duration were assessed.

Results 107 children, median age 10 months (interquartile range [IQR] 5.0–23.0), median weight 6.6 kg (IQR 5.3–9.5), underwent endoscopic GJT placement using the gastric stoma to introduce the endoscope (one step: n = 36/107; 33.6%). Endoscopic placement was successful in 99%. Eight peri-procedure complications occurred: one pneumoperitoneum requiring exsufflation, two acute pulmonary hypertension episodes leading to death in one case, and five episodes of bronchospasm. Minor complications were frequent and mostly mechanical (79%) while major complications were rare (5.6%): intussusception (n = 4), intestinal perforation (n = 1), pneumoperitoneum (n= 1). Ten patients died. Of 97 patients, 85 (87%)

were weaned from JF after a median duration of 179 days (IQR 69–295). Among them, 30 (35.2%) needed a fundoplication. Weight for age Z-score increased significantly.

Conclusions GJT placement is feasible in children, even low-weight infants. Complications are frequent but mostly minor.

When oral feeding is impossible or unsafe, intragastric nutrition is recommended as the treatment of choice because it is the most physiologic and involves easy enteral access. However, in some cases, gastric feeding is poorly tolerated, and post-pyloric nutrition (i.e., jejunal feeding) may be required. The primary indicator of a need for jejunal feeding (JF) in children is gastric feeding intolerance due to severe gastroesophageal reflux disease (GERD) and/or delayed gastric emptying [1]. JF is considered as an alternative to surgical fundoplication, particularly when the patient has comorbidity and/or is severely underweight.Feedings can be administered through a nasoduodenal tube, a jejunostomy, or a gastrojejunal tube (GJT). The GJT allows both jejunal feeding and stomach access for administration of medication and/or exsufflation. A GJT can be placed through a previous gastrostomy or in a one-step procedure when the patient has no previous gastrostomy. Published experience of GJTs in children is limited, especially for low-weight infants [2–5].

The main objective of the present study was to evaluate the feasibility of endoscopic GJT placement in children, regardless of the presence of a previous gastrostomy. Secondary objectives were to assess the rate of GJT complication, longevity of devices, efficacy of JF on nutritional status, and duration.

Methods

All children aged <18 years who underwent a GJT placement at the Lille University Jeanne de Flandre Children's Hospital between January 2010 and December 2019 were included in the study. Children who had surgical jejunostomy or nasoduodenal tube were excluded from the analysis. The GJT was placed under general anesthesia in the operating room or under sedation (nitrous oxide and/or midazolam) when a gastrostomy tract was preexisting.

The one-step technique used an AVANOS® (Alpharetta, GA, USA) introducer kit for the gastrostomy feeding tube as previously described (Annex 1; available at www.jpeds.com) [4]. Once the gastropexy was performed with three fasteners, the stomach tract was created using a trocar and a dilator was introduced on a guidewire. The pylorus was catheterized using a neonatoscope (Olympus® GIF-XP190N, 5.8 mm diameter) introduced through the dilator and placed as far as possible into the jejunum. A guidewire was inserted into the endoscope through, then the endoscope was removed and the GJT was placed into the jejunum on the guidewire. Correct positioning of the device was determined by fluoroscopy.

If a gastrostomy had been performed more than 3 months earlier, the standard technique was used [4]. A neonatoscope (Olympus GIF XP190N, 5.8 mm) was introduced via the gastrostomy tract, and the endoscope was advanced as far as possible into the jejunum. A guidewire was inserted through the operating channel of the endoscope leading to the insertion of a 16-French GJT (AVANOS MIC Gastric-Jejunal feeding tube® (Alpharetta, GA, USA)). The positioning of the GJT was determined by fluoroscopy. When needed, a dilation of the gastrostomy from 6 to 9 mm diameter was performed using Hegar bougies before gastroscopy.

We evaluated the success of endoscopic GJT placement, with or without general anesthesia. Demographics, underlying disease, indication for GJT placement, and feeding modality before the GJT placement (oral, enteral, parenteral, or mixed) were recorded for every patient. Complications related to the GJT, number of tubes replaced, longevity of devices, duration of JF, and date of fundoplication when performed were also recorded.

Peri procedural complication was defined as a complication occurring in the first 24 hours after tube placement. Major complications were defined by the need for hospitalization, urgent removal of the GJT, surgical management, or by a complication leading to death. Minor complications were defined by the need for a medical visit or an unusable tube

requiring non urgent replacement. They included tube leakage, dislodgment, luminal blockage, tube displacement, balloon breaking, granuloma, and skin infection.

Nutritional status and growth at the time of GJT placement, at one month, 6 months, and at weaning from the JF were evaluated with weight for height (W/H) and weight for age (W/A) Z-scores. Undernutrition was defined by a W/A or W/H Z-score < –2. Children were considered weaned from JF if the feeding route was either gastric or oral, or both.

Statistics

Quantitative variables were described by mean and standard deviation (SD) or median and interquartile range (IQR) and/or range. Qualitative variables were described by frequency and percentage. Qualitative variables were compared by Chi-square test or Fisher's exact. Student's t-test and the Mann–Whitney test were used for quantitative variables. SAS software version 9.4® (Cary, NC, USA) was used for the analyses. A *P*-value < 0.05 was considered significant.

Ethics

This research was conducted in accordance with standard protocols, good clinical practice, and the relevant laws and regulations in France. An information letter and an opposition form were given to the patient's parents. In case of opposition, data were not collected or were immediately removed from the database. The study had approval (DEC16-270) from the Commission Nationale de l'Informatique et des Libertés (CNIL, French Data Protection Authority).

Results

A total of 107 children (52 girls; 48.6%) underwent a GJT placement during the study period (Table I). At the time of the first GJT placement, children were aged 10 months (median, IQR 5.0-23.0); 55% of them were < 1 year of age. Median weight at the first GJT placement was 6.6 kg (IQR 5.3-9.5 kg). Mean W/H Z-score was –1.0 (± 1.6) and W/A Z-score was –2.6 (± 1.8) at time of placement (Table I).

Most of the children were undernourished (45% had W/A Z-score < –2 and 10% W/H Z-score < –2) at the time of GJT placement; 95%had at least one associated comorbidity (Table II). The main indication for JF was GERD (n = 91, 85%). Other indications included delayed gastric emptying (n = 32; 29.9%) and aspiration (n = 22; 20%). More rarely, the indication was intestinal pseudo-obstruction (n = 3), toddler anorexia with induced vomiting (n = 1), and persistent peristomal leakage from the gastrostomy making intragastric nutrition impossible (n = 1). Nine patients (8%) had anti-reflux surgery prior to the first GJT placement, including eight fundoplication and one esophagogastric disconnection.

Thirty-six children (33%) had no preexisting gastrostomy and underwent a one-step GJT placement, and 71 had a preexisting gastrostomy. Most GJTs were placed under general anesthesia (n = 75, 70%); however, because of preexisting gastrostomy, 32 GJTs (30%) were placed under sedation (oral midazolam + nitrous oxide ± hypnosis). 39 children with a preexisting gastrostomy had their first placement under general anesthesia when they needed associated procedure such as intra-pyloric botulinum toxin injection, esophageal dilatation, digestive biopsies, and/or otorhinolaryngology procedures. Children in the “no preexisting” gastrostomy group were younger and lower in weight than the rest of the cohort (Table I).

GJT placement was successful in 106/107 children. The only failure was related to a major pneumoperitoneum after tube insertion due to gastrostomy leakage (performed 74 days

earlier) needing surgical placement with a noncomplicated final outcome. For 3 children, GJT placement failed under sedation requiring subsequent general anesthesia; no complication was recorded. Among children with a previous gastrostomy, the mean ± SD time between the gastrostomy and GJT placement was 495.7 ± 634.8 days (median at 180 days).

Median duration of follow-up was 12 months (range 0-111). Peri procedural complications were observed in 8 patients (7.4%): one pneumoperitoneum requiring exsufflation, one cardiac arrest related to pulmonary hypertension that could be resuscitated without sequelae, an acute pulmonary hypertension after general anesthesia leading to death and five bronchospasms. No death resulted directly from the GJT placement, but a child suddenly died with a GJT in place. The autopsy was refused by the parents, the hypothesis was death caused by pulmonary hypertension. Eighty five/107 (79%) children had at least one minor complication, the most frequent being tube breakage, dislodgement, luminal blockage, intragastric jejunal tube displacement (Table III). Six (5.6%) patients had major late complications: four confirmed jejunal intussusception (one complicated by bacterial translocation), one intestinal perforation diagnosed 48 hours after the placement, one pneumoperitoneum after tube replacement leading to surgery. Of the total reported days of JF (n = 21402), a minor complication occurred every 102 days and a major one every 3567 days. Ten children died before weaning, all from progression of their underlying chronic disease.
In this study we found a significant association between being underweighted (under 6 kg, 5/39 versus 1/62 (p=0.03)), young age (under 12 months, 6/59 versus 0/48 (p= 0.03)) and major complications. We also found a higher risk of periprocedural complication in the groups of young age (8/59 versus 0/48 (p= 0.008)), cardiac disease (6/25 versus 2/82 (p= 0.019)) and respiratory comorbidity (5/29 versus 3/78 (p=0.03)).

The mean number of tube replacements was 2.1 ± 2.3 (range, 0–10) for the whole follow-up for each child. Replacement was related to mechanical complications in 75% of cases (Table III). Median GJT life duration was 70.0 days (range, 1–558).

At maximal follow-up, 85/97 children (87%) were weaned off JF after a median duration of 179 days (IQR 69.0-295.0; range, 0-1156), at mean age of 28.9 ± 34.3 months. Thirty-four (40%) children converted to exclusive intragastric enteral feeding, 3 (3%) to exclusive oral feeding, and 41 (48%) to both (and 7 missing data). Fundoplication was performed in 30/85 (35%) of patients on average 286 days after the first GJT placement (range, 22-1156 days). Interestingly, 55 children (65%) could be weaned off GJT without requiring any fundoplication.

GJT placement was indicated for GERD (n=15), GERD and aspiration (n=10), GERD and delayed gastric emptying (n=4) and isolated delayed gastric emptying (n=1) in an adolescent with neurological impairment (fundoplication was associated with a pyloroplasty). We found a significant association between the need of fundoplication and having a respiratory comorbidity at first placement (13/22 when respiratory problem versus 16/60 when no respiratory problem, p= 0.0108), and having GERD (29/91 versus 1/16, p= 0.0374) and/or aspiration (11/23 versus 19/85, p= 0.018). No significant link was found with having neurological impairment.

Two children remained on long-term JF (maximum follow-up, 978 days) and 2 patients needed to start long-term parenteral nutrition because of chronic intestinal pseudo-obstruction.

Mean W/A Z-score was – 2.4 before GJT placement and improved to –1.7 at time of JF weaning or death ($P < 0.001$). W/H Z-score varied from –1.2 to –0.6 at the end of follow-up ($P = 0.2$) (Figure; available at www.jpeds.com).

Discussion

Our results show that endoscopic GJT placement is a feasible technique in children with less than 1% failure rate, even in young and low-weight infants with severe underlying disease. A prior report of older children (average age 5 years) [6]; our study showed that this technique is also viable in infants. The cohort reflects our recruitment position as a tertiary referral center for severe neonatal and infant diseases and our policy to postpone, whenever possible, fundoplication in this young and fragile population.

We reported frequent but minor complications. We found mechanical complications (tube breakage, dislodgement, luminal blockage, intragastric jejunal tube displacement) to be the more common complications leading to frequent GJT change as described by Godbole et al [7]. In our series, 80% of complications progressed to GJT replacement (17% performed under general anesthesia). This observation constitutes a major drawback of this technique and is an obstacle to its prolonged use. Use of a gastrojejunal button rather than tube could be an alternative. Gill et al [8] found that gastrojejunal button prevents leakage from the tube at the site of connection between the external catheter and the jejunal tube, but would not prevent obstruction or retrograde displacement of the tube through the stomach.

Alternative techniques have been proposed to prevent retrograde dislodgment such as endoscopic clipping of the tip of the jejunal tube. This technique requires the introduction of the endoscope through the upper gastrointestinal tract and attachment to the GJT with grasp

forceps, rather than using the transgastrostomy route. Opening a clip in an infant duodenum could be technically difficult because of its size. An alternative to prevent recurrent GJT dislodgments, is to suture the proximal end of the jejunal tube to the gastric wall. [9] This prevents intragastric loop and dislodgment. To our knowledge, this technique has never been attempted in children.

The originality of our approach is the use of the gastric stoma to introduce the endoscope and therefore avoid the upper gastrointestinal route. Michaud et al. [4] described this technique in 3 infants. This avoids repeated general anesthesia for initial placement or replacement (in 83% of the cases) and prevents removal of the jejunal tip if it is stuck to the endoscope (unless a clip is placed, as mentioned above). This technique was also reported in another study [10] showing it can reduce fluoroscopy exposition.

One major complication recorded was intestinal perforation, which occurred in a 5-month-old infant (weighting 7.8 kg), 48 hours after GJT placement. Surgeons identified the perforation at the Treitz level, and a jejunostomy was performed at the same time. A few similar cases have been reported in the literature. Campwala et al. described an intestinal perforation rate of 3.2% with a higher risk for infants under 12 months of age [6]. Their hypothesis was that the intestinal wall is thin at this age and that a large diameter tube could increase the risk. Both Massoumi [11] and Demehri [12] found 5% intestinal perforation in low-weight infants (respectively, 10 and 5 kg). Haubaugh et al. associated a higher risk of perforation with a rigid tube in children < 10 kg [13]. In our experience, in infants weighing < 10 kg the incidence was 1.3%. This observation confirms our practice of using thin silicone tubes (AVANOS® MIC* Transgastric-Jejunal Tube) in infants < 8 kg even if migration is more frequent, and limiting the use of the more rigid polyurethane tubes (AVANOS® MIC* Gastro-Enteric Feeding Tube) for children weighing > 8 kg. We found a significant association between low weight and/or young age and peri-procedural and major

complications, probably related to our very young population with severe comorbidities. We also found higher risk of peri-procedural complications in cardiac disease and/or respiratory comorbidity group, leading us to be cautious about the pre-anesthetic preparation when needed.

Our work raises the question of the respective role of JF versus fundoplication in severe GERD. recommendations [1,14] state that JF can be considered in the treatment of neurologically impaired infants and children with refractory GERD as an alternative for fundoplication. In this context, it is important to balance the benefits against the disadvantages of both strategies. We do not deny there are complications of percutaneous GJ but emphasize that fundoplication also involves failure and complications, especially in infancy [15–18]. Our study also shows that up to 65% of children receiving a GJT because of severe GERD could finally be weaned off JF without needing any fundoplication. We found significant association between need of fundoplication and having aspiration and/or GERD, which is not surprising. I we did not find and higher risk in neurological impairment group.

Other post-pyloric feeding techniques could be alternatives to the endoscopic GJT placement we used in our study. Endoscopic percutaneous jejunostomy is widely used in adults. Lim et al. described a 10-year cohort with a 90% success rate and a low rate of serious complications (1.2%) [19]. Virnig et al. reported the placement of direct endoscopic percutaneous jejunostomy in 5 children (aged 4–17 years) without major complications [20]. Belsha et al. [21] described a technique for setting up an endoscopic jejunostomy with laparoscopic guidance in a group of children (average age 6.5 years). Small bowel volvulus requiring intestinal resection was the only major complication encountered in 2 patients with abnormal gastrointestinal anatomy. Although these two techniques appear to result in more durable jejunal access than a GJT, they do not allow for administration of medication or exsufflation of the stomach and are mostly reported in older children, adolescents, or adults.

Surgical jejunostomy is also a possible technique that has been reported in the pediatric population. Fascetti-Leon et al. reported a high rate of major complications (36%) including three jejunal perforations, one volvulus, one bowel obstruction, one incisional hernia, and one severe peristomal ulceration; this rate is higher than that observed in our series [22].

Endoscopic gastrojejunal tube placement using of the gastric stoma to introduce the endoscope is a feasible technique in children even in underweight infants. Complications are frequent but usually minor. Jejunal nutrition weaning is possible for most of the patients without further need for fundoplication. Endoscopic GJT placement is an acceptable therapeutic option for severe GERD and/or delayed stomach emptying and/or aspiration in infants in expectation of spontaneous improvement or for nutritional catch-up in cases of severe malnutrition.

List of abbreviations

JF	Jejunal feeding
GJT	Gastrojejunal tube
IQR	Interquartile range
GERD	Gastroesophageal reflux disease
W/H	Weight for height
W/A	Weight for age
SD	Standard deviation
CNIL	French data protection authority

Acknowledgement: in memory to Dr Laurent Michaud who inspired this study

References

1. Rosen R, Vandenplas Y, Singendonk M, Cabana M, DiLorenzo C, Gottrand F,et al. Pediatric gastroesophageal reflux clinical practice guidelines: Joint recommendations of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition. J Pediatr Gastroenterol Nutr. 2018.

2. Livingston MH, Shawyer AC, Rosenbaum PL, Jones SA, Walton JM. Fundoplication and gastrostomy versus percutaneous gastrojejunostomy for gastroesophageal reflux in children with neurologic impairment: A systematic review and meta-analysis. J Pediatr Surg. 2015.

3. Morse J, Baird R, Muchantef K, Levesque D, Morinville V, Puligandla PS, et al. Gastrojejunostomy tube complications - A single center experience and systematic review. J Pediatr Surg. 2017.

4. Michaud L, Robert-Dehault A, Coopman S, Guimber D, Turck D, Gottrand F, et al. One-step percutaneous gastrojejunostomy in early infancy. J Pediatr Gastroenterol Nutr. 2012.

5. Michaud L, Coopman S, Guimber D, Sfeir R, Turck D, Gottrand F, et al. Percutaneous gastrojejunostomy in children: efficacy and safety. Arch Dis Child. 2012.

6. Campwala I, Perrone E, Yanni G, Shah M, Gollin G. Complications of gastrojejunal feeding tubes in children. J Surg Res. 2015.

7. Godbole P, Margabanthu G, Crabbe DC, Thomas A, Puntis JWL, Abel G, et al. Limitations and uses of gastrojejunal feeding tubes. Arch Dis Child. 2002.

8. Gill AE, Gallagher N, McElhanon BO, Painter AR, Gold BD, Hawkins CM, et al. Image-guided placement of percutaneous de novo low-profile gastrojejunostomy tubes in the pediatric population: a study of feasibility and efficacy. Pediatr Radiol. 2018.

9. Agnihotri A, Barola S, Hill C, Mishra P, Fayad L, Dunlap M, et al. Endoscopic suturing for the management of recurrent dislodgment of percutaneous endoscopic gastrostomy-jejunostomy tube. J Dig Dis. 2018.

10. Picoraro JA, Pierog, A, Reilly NR, Mencin AA. Gastrojejunal tube placement through an established gastrostomy via an endoscopic transgastric approach in a pediatric population. Gastrointestinal endoscopy 2015.

11. Massoumi RL, Abdelhafeez AH, Christensen MA,Vo JN, Goday PS, Leack KM, et al. Gastrojejunostomy tube bowel perforations in low-weight infants. JPEN J Parenter Enteral Nutr. 2016.

12. Demehri FR, Simha S, Herrman E, Jarboe MD, Geiger JD, Teitelbaum DH, et al. Analysis of risk factors contributing to morbidity from gastrojejunostomy feeding tubes in children. J Pediatr Surg. 2016.

13. Harbaugh CM, Wu C, Demehri F, Gadepalli SK, Ehrlich PF. Impact of practice change on intestinal perforation risk for pediatric gastrojejunostomy tube placement. J Pediatr Surg. 2019.

14. Broekaert IJ, Falconer J, Bronsky J, Gottrand F, Dall'OglioL, Goto E, et al. The use of jejunal tube feeding in children: A position paper by the gastroenterology and nutrition committees of the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition 2019. J Pediatr Gastroenterol Nutr. 2019.

15. Baerg J, Thorpe D, Gasior A, Vannix R, Tagge E, St Peter S, et al. Factors associated with mortality after Nissen fundoplication in children. Eur J Pediatr Surg. 2015.

16. Rothenberg SS. Two decades of experience with laparoscopic nissen fundoplication in infants and children: a critical evaluation of indications, technique, and results. J Laparoendosc Adv Surg Tech A.

17. Laje P, Blinman TA, Nance ML, Peranteau WH. Laparoscopic fundoplication in neonates and young infants: Failure rate and need for redo at a high-volume center. J Pediatr Surg. 2017.

18. Marret J-B, Dupont-Lucas C, Petit T, Menahem B, Godet C, Ravasse P, et al. Safety of laparoscopic fundoplication in children under 5 kg: a comparative study. Surg Endosc. 2018.

19. Lim AH, Schoeman MN, Nguyen NQ. Long-term outcomes of direct percutaneous endoscopic jejunostomy: a 10-year cohort. Endosc Int Open. 2015.

20. Virnig DJ, Frech EJ, Delegge MH, Fang CJ. Direct percutaneous endoscopic jejunostomy: a case series in pediatric patients. Gastrointest Endosc. 2008.

21. Belsha D, Thomson M, Dass DR, Lindley R, Marven R. Assessment of the safety and efficacy of percutaneous laparoscopic endoscopic jejunostomy (PLEJ). J Pediatr Surg. 2016.

22. Fascetti-Leon F, El Agami H, Gobbi D, Clarke S, Haddad M, Choudhry M et al. Feeding jejunostomy: Is it a safe route in pediatric patients? Single institution experience. Eur J Pediatr Surg. 2018.

Table 1 Characteristics of the population and indication for gastrojejunal tube placement.

	One-step GJT (n = 36)	Previous gastrostomy (n = 71)	Total (n = 107)	Groups comparison (p value)
Age (months, median (IQR))	7.0 (5.0–11.0)	14.0 (8.0–33.0)	10.0 (5.0–23.0)	< 0.001
Weight (kg, median, IQR)	5.6 (4.8–6.5)	8.0 (5.7–12.3)	6.6 (5.3–9.5)	<0.001
Sex ratio (F/M)	17/19	35/36	52/55	1.0
W/A Z-score (mean ± SD)	–3.1 ± 1.2	–2.0 ± 1.9	–2.6 ± 1.6	0.002
W/H Z-score (mean ± SD)	–0.7 ± 1.6	–1.2 ± 1.5	–0.9 ± 1.6	0.1142
GERD	34 (94%)	57 (80%)	91 (85%)	0.08
Delayed stomach emptying	10 (27%)	22 (30%)	32 (29%)	0.82
Aspiration	7 (19%)	15 (21%)	22 (20%)	1.0
Intestinal pseudo-obstruction	0	3 (4%)	3 (3%)	0.54
Toddler anorexia	0	1 (1.5%)	1 (1%)	1.0
Gastrostomy peristomal repeated leakage	0	1 (1.5%)	1 (1%)	1.0
Fundoplication	9 (25%)	21 (29%)	30 (28%)	0.97
Minor complications	29 (80%)	56 (79%)	85 (79%)	0.73
Major complications	2 (5%)	4 (5%)	6 (5%)	NA

(W/A Z-score, weight for age Z-score; W/H Z-score, weight for height Z-score; GJT, gastrojejunal tube; IQR, interquartile range).

Table 2 Underlying conditions of the children included in the study.

	One step GJT (n = 36)	Previous gastrostomy (n = 71)	Total (n =107)
Neurological impairment	14 (38%)	24 (33%)	38 (35%)
Cardiac diseases	12 (33%)	14 (19%)	26 (24%)
Respiratory diseases	14 (38%)	15 (21%)	29 (27%)
Diaphragmatic hernia	1 (3%)	8 (11%)	9 (8%)
Esophageal atresia	0	7 (10%)	7 (6%)
Feeding disorders*	19 (52%)	36 (50%)	55 (51%)
Metabolic disease	1 (3%)	7 (10%)	8 (7%)
Ear, nose, and throat diseases	12 (33%)	29 (40%)	41 (38%)

*Heterogeneous groups including premature babies, severe gastroesophageal reflux.

Table 3 Minor late complications observed after endoscopic gastrojejunal tube placement.

Complication	Total (n = 209)
Tube breakage	71
Tube dislodgment	40
Luminal blockage	30
Intra-gastrojejunal tube displacement	30
Balloon breaking	13
Tube leaking	7
Granuloma at the site of gastrostomy	6
Digestive symptoms (diarrhea, vomiting)	6
Accidental cutting of the tube	3
Intra-pyloric balloon obstruction	2
Skin infection	1