Received: 16 November 2022 | Revised: 11 March 2023 | Accepted: 18 April 2023

DOI: 10.1111/apa.16792

ACTA PÆDIATRICA NURTURING THE CHILD WILEY

ORIGINAL ARTICLE

Complication rate after gastrostomy placement in children can be reduced by simple surgical steps

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Funding information
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Abstract

Aim: To evaluate if the incidence of postoperative complications after gastrostomy placement is correlated to perioperative parameters or patient characteristics.

Methods: In this prospective observational study, children <18 years of age planned to receive a gastrostomy at partaking clinics between 2014 and 2019 were invited. Pre-, peri- and postoperative variables were collected and followed up 3 months postoperatively.

Results: Five hundred and eighty-two patients were included (median age: 26 months, median weight: 10.8 kg), mainly laparoscopic (52.0%) and push-PEG (30.2%) technique used. The incidence of complications was lower in the group of patients receiving a gastrostomy tube that was 2 mm longer than the gastrostomy canal ($p < 0.001–0.025$), and a thickness of 12 Fr ($p < 0.001–0.009$). These findings were confirmed by multivariate analysis also including operative technique, age and weight. Patients with oncological disease had significantly higher incidence of pain and infection but the lowest incidence of granulomas ($p < 0.001–0.01$).

Conclusion: This study indicates that a 12 Fr gastrostomy tube that is 2 mm longer than the gastrostomy canal is correlated with the lowest incidence of postoperative complications the first 3 months after surgery. Oncological patients had the lowest incidence of granulomas which probably is related to chemotherapy.

KEYWORDS
gastrostomy, paediatric surgery, postoperative complications, tube feeding

Abbreviations: CI, confidence interval; F, family; Fr, French; HC, healthcare staff; OR, odds ratio; PEG, percutaneous endoscopic gastrostomy.

1 | INTRODUCTION

Placement of a gastrostomy is indicated in children with long-term need of enteral nutrition where oral intake is inadequate, and there is at least a partially functioning digestive tract and/or if the child needs specific diet or medication that is difficult to administer perorally.[1]

Children in need for gastrostomy usually have an underlying disease such as neurodevelopmental disorder, failure to thrive, cancer, metabolic disorder or gastrointestinal failure.[2] The gastrostomy operation includes creation of a channel through the stomach- and abdominal wall with placement of a tube. The tube is secured inside the stomach with a device, most commonly a waterfilled balloon. The tube keeps the channel open and enables feeding and medication.

There are several different operative techniques to establish a gastrostomy: laparoscopic, percutaneous, radiologically assisted and open techniques. Some researchers consider the laparoscopic approach to be the most preferable and safe option while others prefer the percutaneous or open technique.[3–6] Regardless of operative technique, the placement of gastrostomy is correlated with few major complications, but commonly seen are several minor complications. Granulomas are the most common minor complication seen in as many as 40%–60% of patients, followed by infections 2%–30%, leakage 3%–24% and dislocation 4%–21%.[4,5,7,8] There are international guidelines concerning indications and use of gastrostomies but there is a lack of evidence in how to treat minor complications.[9,10]

In 2013, the Swedish Paediatric Surgery Association formed a national group with the goal to establish national guidelines for pre- and postoperative care of gastrostomies. When these guidelines were established a non-randomised national prospective study on gastrostomies and their complications was initiated. The database derived from this study was intended to be used as a starting point for further studies on this topic.

The primary aim of this study was to investigate possible correlations between the chosen size of the gastrostomy tube and the incidence of postoperative complications. The secondary aim was to investigate whether complications were more common for any specific subgroup of patients or correlated to the operative method.

Key notes

- More than half of children receiving a gastrostomy are affected by minor postoperative complications such as infections and granulomas.
- There is a shortage of knowledge regarding complications in relation to adjustable perioperative parameters, such as size of the gastrostomy.
- This nationwide observational study indicates that a gastrostomy tube of size 12 Fr and 2 mm longer than the gastrostomy canal correlates with fewer postoperative complications 3 months after surgery.

2 | METHODS

2.1 | Study design and data collection

A national prospective observational multi-centre study with collection of data was conducted in 2014–2020. Partaking clinics were the four departments of paediatric surgery in Sweden at the University hospitals of Uppsala, Stockholm, Gothenburg and Lund, and the department of surgery at Umeå University hospital, partaking from 2017. The majority of gastrostomy operations on children in Sweden were performed in the departments involved in this study.

The study included four non-validated questionnaires, in total 86 different variables were collected. The first questionnaire was completed by the surgeon postoperatively. The second questionnaire was completed at the routine return visit 3 months postoperatively, when the first change of the gastrostomy took place. This change was generally performed by a specialist nurse practitioner, who completed the questionnaire in most cases. In few cases, the questionnaire was completed by a present doctor. The remaining two questionnaires were completed by the families, at 3 and 12 months postoperatively. The operative questionnaire collected data on patient demographics and characteristics as well as perioperative data such as operative technique, type and size of gastrostomy device, the relation between the length of the gastrostomy canal and the length of the gastrostomy button, the use of prophylactic antibiotics, any concomitant surgery, operative time as well as total patient time in the operating room. When measuring the gastrostomy canal, this was done in different fashions depending on local traditions and the surgical technique utilised: When doing a Push-PEG, a measurement tool was used. When performing open or laparoscopic surgery, the abdominal wall was measured either with a needle or a graded measurement tool, and the thickness of the stomach wall was added to this measurement. In patients receiving an adjustable catheter-type gastrostomy, this thickness was not measured. The 3-month questionnaire filled in by medical staff collected data on postoperative complications including granuloma, pain (defined as pain from the gastrostomy site during the postoperative period, experienced by the families/patients), dislocation, leakage and infection (including all patients treated with oral or topical antibiotics postoperatively). It also collected data on treatment of complications, healing, cosmesis, function of the gastrostomy and if any reoperation had been performed. The questionnaires filled in by the families at 3 and 12 months were identical. The family questionnaires collected the families view on the incidence of complications and data on treatment of any complication, as well as function and cosmesis.

The aim of this article was to evaluate the correlation between pre- and perioperative parameters and the incidence of postoperative complications. We believe that the effect of operation is of more importance the first 3 months postoperatively than after 1 year. Therefore, we have chosen not to analyse data from the 12-month follow-up questionnaires in this article. Neither is data on function,

cosmesis, operative time and total time in the operating room examined in this article.

2.2 | Participants

All children 0–18 years scheduled for a gastrostomy operation at any of the partaking clinics were invited to the study by the operating surgeon. Exclusion criteria were if the families were deemed not to be able to adhere to the follow-up. Additionally, the patient was excluded if only the operative questionnaire but none of the follow-up questionnaires were completed.

A total of 681 patients had data collected from the operative questionnaire as well as at least one of the three follow-up-questionnaires and were included in the study. At the time of operation, the median age was 26 months (range: 0–215 months) and the median weight was 10.8 kg (range: 1.5–84 kg). Underlying reasons for gastrostomy and operation techniques used are presented in Table 1. Patients were subdivided into five main groups for underlying reasons, and patients with rare reasons that did not fit well into any of the main groups were put in the miscellaneous group.

In 99 of the 681 patients included in the study, none of the 3-month questionnaires were returned, hence they were excluded from the data set of this article. The remaining 582 patients had at least one questionnaire filled in and were included in the data set of this article. When responding to questionnaires some answers were omitted. Therefore, the numbers reported for different parameters can be less than the total number of patients followed-up.

TABLE 1 Underlying reason for gastrostomy and operative technique used.

	N = 681	%
Reason for gastrostomy		
Neurologic	315	46.3%
Food refusal	106	15.6%
Miscellaneous	68	10.0%
Metabolic	62	9.1%
Cardiac	60	8.8%
Oncologic	50	7.3%
Data missing	20	2.9%
Operative technique		
Laparoscopic	354	52.0%
Push-PEG	206	30.2%
Open	76	11.2%
Pull-PEG	26	3.8%
Laparoscopic-assisted Push-PEG	16	2.3%
PEG with transgastric jejunal tube	1	0.1%
Data missing	2	0.3%

Abbreviation: PEG, percutaneous endoscopic gastrostomy.

2.3 | Statistical analysis

Statistica 13 software (TIBCO, Palo Alto, California, USA) was used for statistical analysis except for multivariate analysis. Values are presented as proportions, means and range where appropriate. The chi-square test was used to compare proportions. Yates's correction was applied to the chi-square test when any of the numbers in the calculation were 10 or below. Multivariate analysis was performed in R v 4.1.1 (The R Foundation). A $p < 0.05$ was considered statistically significant. If a confidence interval (CI) was calculated, a $p < 0.05$ and a CI not including 1 was considered significant.

3 | RESULTS

The results are first presented for each group and thereafter as a combined multivariate analysis.

3.1 | Complications in general

Healthcare staff (HC) reported some sort of complication in 72.0% and the families (F) in 69.1% during the first 3 months, Figure 1. Some patients were affected by several different complications.

3.2 | Complications in relation to underlying reason for receiving gastrostomy

Since the most common underlying reason for receiving a gastrostomy was neurological, this group was set as reference group and the incidence of each complication in other groups was compared to the reference, (Table 2). The incidence of reported pain and infections was significantly higher for oncological patients. However, the oncological patients had significantly lower incidence of granulomas. Patients with the underlying reason of food refusal reported a significantly higher incidence of leakage and infections according

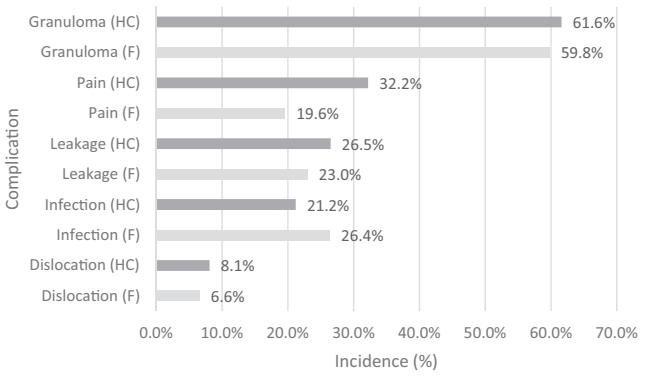

FIGURE 1 Complications reported by healthcare staff (HC) and families (F).

TABLE 2 Postoperative complications during the first 3 months after gastrostomy placement, reported by healthcare staff and families.

Complication	Neuro logic *N* = 277	Food refusal *N* = 88	Miscellaneous *N* = 54	Metabolic *N* = 51	Cardiac *N* = 53	Oncologic *N* = 44
Granuloma (HC)	63.6%	69.9% (0.21)	66.0% (0.61)	61.2% (0.82)	48.1% (0.05)	44.2% **(0.01)***
Granuloma (F)	62.5%	67.1% (0.21)	58.5% (0.23)	62.5% (0.81)	46.0% **(0.006)***	44.2% **(0.003)***
Pain (HC)	29.9%	38.6% (0.13)	32.1% (0.89)	30.6% (0.91)	17.3% (0.076)	55.8% **(<0.001)***
Pain (F)	14.5%	29.3% (0.06)	22.6% (0.22)	22.9% (0.14)	6.0% (0.10)	46.5% **(<0.001)***
Leakage (HC)	24.3%	35.4% **(0.03)***	34.0% (0.10)	24.5% (0.93)	15.4% (0.20)	32.6% (0.15)
Leakage (F)	21.6%	32.9% (0.19)	18.9% (0.53)	29.2% (0.22)	12.0% (0.14)	25.6% (0.56)
Infection (HC)	16.2%	30.1% **(0.005)***	24.5% (0.46)	22.4% (0.28)	21.2% (0.35)	34.9% **(0.005)***
Infection (F)	21.6%	36.6% (0.07)	32.1% (0.07)	31.3% (0.01)	18.0% (0.28)	44.2% **(0.002)***
Dislocation (HC)	9.9%	4.8% (0.13)	1.9% (0.09)	8.2% (0.65)	7.7% (0.59)	11.6% (0.83)
Dislocation (F)	7.1%	7.3% (0.91)	9.4% (0.95)	6.3% (0.83)	2.0% (0.37)	4.7% (0.91)

Note: Here in relation to underlying reason for gastrostomy. Values in brackets are *p*-values calculated with chi-square test in comparison with the most common reason for gastrostomy. $p < 0.05$ are considered significant and marked with * and bold font.Abbreviations: F, family; HC, healthcare staff.

to healthcare staff but not according to the families. Cardiac patients had a significantly lower incidence of granulomas.

3.3 | Complications in relation to operative technique

The most common operative technique used was laparoscopic, and hence set as reference group when comparing the incidence of each complication in the other groups, (Table 3). In the group operated with push-PEG technique, the incidence of granulomas was significantly higher than in the laparoscopic group, and the incidence of leakage was significantly lower. Patients operated with pull-PEG technique reported a significantly lower incidence of pain according to healthcare staff, but not according to the families.

3.4 | Complications in relation to the exceeding length of the gastrostomy button catheter compared to length of the gastrostomy canal

Most commonly, the inserted gastrostomy button catheter was 2 mm longer than the gastrostomy canal (in 339 out of 490 gastrostomies). This group was set as reference and compared with the incidence of complications in the other groups, (Table 4). The use of a catheter with a length of additional 2 mm to the gastrostomy canal was associated with fewer postoperative complications, compared to other catheter lengths. Significantly higher incidence of complications was reported in six of 10 variables in the 0 and 1 mm groups, in four of 10 variables in the 3 mm group and three of 10 variables in the 5 mm group. When comparing the 2 mm group with all other lengths, the incidence of complications was higher for all variables. In this analysis, patients receiving an adjustable catheter-type gastrostomy were omitted.

3.5 | Complications in relation to thickness of gastrostomy tube

Gastrostomy tubes with outer diameter of 12, 14, 15 or 16 Fr were used in this study. The number of patients receiving a 15 or 16 Fr tube (seven and two patients respectively), were too few to include in the analysis. Comparing the remaining patients, the incidence of granulomas, pain, leakages and infections was significantly lower in the group receiving a 12 Fr tube (Table 5).

3.6 | Multivariate analysis

When performing the multivariate analysis, we included: tube thickness, gastrostomy button catheter length in relation to the gastrostomy canal, operative technique as well as age and weight at surgery

TABLE 3 Postoperative complications during the first 3 months after gastrostomy placement, reported by healthcare staff and families.

Complication	Laparoscopic *N* = 311	Push-PEG *N* = 175	Open *N* = 59	Pull-PEG *N* = 22	Laparoscopic-assisted Push-PEG *N* = 12
Granuloma (HC)	56.4%	67.8% **(<0.001)***	66.7% (0.16)	57.1% (0.37)	75.0% (0.20)
Granuloma (F)	54.3%	68.7% **(0.003)***	61.1% (0.60)	63.6% (0.645)	72.7% (0.22)
Pain (HC)	32.5%	35.7% (0.82)	26.3% (0.45)	4.8% **(0.01)***	41.7% (0.93)
Pain (F)	18.1%	21.7% (0.40)	20.4% (0.63)	9.1% (0.27)	45.5% (0.06)
Leakage (HC)	31.8%	16.4% (0.002)*	26.3% (0.28)	19.0% (0.22)	50.0% (0.83)
Leakage (F)	28.0%	14.5% **(<0.001)***	24.1% (0.61)	13.6% (0.23)	27.3% (0.76)
Infection (HC)	22.4%	21.6% (0.80)	17.5% (0.30)	9.5% (0.26)	25.0% (0.76)
Infection (F)	25.0%	30.7% (0.19)	29.6% (0.56)	13.6% (0.37)	18.2% (0.90)
Dislocation (HC)	8.9%	7.0% (0.39)	8.8% (0.86)	0.0% (0.29)	16.7% (0.81)
Dislocation (F)	7.6%	4.8% (0.25)	9.3% (0.96)	0.0% (0.37)	9.1% (0.65)

Note: Here in relation to operative technique and in comparison with laparoscopic technique as the most common operative technique. Values in brackets are *p*-values calculated with chi-square test. $p < 0.05$ are considered significant and marked with * and bold font. The PEG with transgastric jejunal tube patient was excluded from analysis.Abbreviations: F: family; HC: healthcare staff; PEG: percutaneous endoscopic gastrostomy.

(Table 6). Due to the small numbers of included laparoscopic-assisted push-PEG and pull-PEG-patients as well as patients receiving 15 and 16 Fr tubes and patients with >3 mm length of catheter compared to the gastrostomy canal, they had to be excluded from the analysis. Furthermore, all patients receiving a gastrostomy tube or PEG had to be omitted from analysis since there was no fixed tube length in relation to the abdominal wall, making their inclusion in the analysis mathematically impossible. A gastrostomy button size 12 Fr was associated with a significantly lower incidence of granulomas, pain, leakage and infections regardless of operative technique, excess length of the gastrostomy catheter, age or weight at the time of surgery. Excess length of the gastrostomy tube of 2 mm compared to the gastrostomy canal had significantly lower incidence of granulomas than 3 mm. A higher body weight was correlated to a higher incidence of postoperative pain.

3.7 | Incidence of infections in relation to administration of antibiotic prophylaxis

Postoperative infection was reported in 20.6% (HC), 25.8% (F) in the group treated with antibiotic prophylaxis, and 20.0% (HC) and 22.0% (F) in the group without antibiotic prophylaxis. Hence, there was no correlation between the use of perioperative antibiotic prophylaxis and the incidence of postoperative infections during the first three postoperative months.

4 | DISCUSSION

Children receiving gastrostomies belong to a vulnerable group of patients, with many co-morbidities and with a great need for healthcare. Our study shows that approximately two thirds are affected by one or more minor postoperative complications that usually requires, one or more, acute or sub-acute medical visits. Several studies are consistent in the high rate of postoperative revisits (8%–9%) to the emergency department the first months after gastrostomy placement in children.[11–13] Our results on minor postoperative complications also correspond well with previously published studies where the reported incidence varies between 54% and 74%,[4,5,7,8] although it is difficult to compare between studies due to different follow-up times. Placement of gastrostomies is one of the most common gastrointestinal in-patient care interventions in children, and therefore, it is of great interest both for the families and healthcare, to carry through the hospital stay and follow-up as safe and complication-free as possible.

This study found a benefit of using a 12 Fr tube with a lower incidence of granuloma, pain, leakage and infection compared to a 14 Fr tube. This was also confirmed in the multivariate analysis which strengthens the reliability and, in to some extent, adjust for confounders. This indicates that the surgeon should choose a 12 Fr tube if possible, depending on the intended use of the gastrostomy. For example, some patients might need a larger diameter of the tube if they are going to receive mixed food instead of specialised formula,

TABLE 4 Complications reported, by healthcare staff and families, in relation to how much the catheter length exceeded the length of the gastrostomy canal, and in comparison with 2 mm exceeding length.

Complication	0 mm *N* = 42	1 mm *N* = 60	2 mm *N* = 339	3 mm *N* = 36	4 mm *N* = 9	5 mm *N* = 4	Length other than 2 mm *N* = 151
Granuloma (HC)	61.5% (0.39)	70.0% **(0.02)***	54.2%	80.0% **(0.003)***	55.6% (0.79)	100.0% (0.11)	72.2% **(0.00015)***
Granuloma (F)	55.3% (0.64)	68.5% **(0.04)***	53.3%	88.6% **(<0.001)***	66.7% (0.63)	75.0% (0.45)	68.9% **(0.001337)***
Pain (HC)	46.2% **(0.03)***	43.3% **(0.01)***	28.9%	37.1% (0.36)	33.3% (0.94)	75.0% (0.30)	42.4% **(0.001455)***
Pain (F)	23.7% (0.24)	24.1% (0.20)	16.7%	25.7% (0.18)	33.3% (0.39)	25.0% (0.69)	25.9% **(0.0161)***
Leakage (HC)	48.7% **(<0.001)***	36.7% **(0.004)***	19.7%	31.4% (0.13)	22.2% (0.81)	100.0% **(0.004)***	39.1% **(<0.00001)***
Leakage (F)	34.2% **(0.004)***	35.2% **(0.001)***	16.4%	31.4% (0.02)*	33.3% (0.35)	75.0% **(0.04)***	34.4% **(<0.00001)***
Infection (HC)	33.3% **(0.01)***	30.0% (0.02)*	17.0%	17.1% (0.71)	33.3% (0.41)	50.0% (0.39)	28.5% **(0.0031)***
Infection (F)	44.7% **(<0.001)***	29.6% (0.15)	20.6%	34.3% (0.06)	33.3% (0.6060)	100.0% **(0.004)***	37.1% **(0.0000121)***
Dislocation (HC)	10.3% (0.36)	13.3% (0.06)	6.4%	17.1% **(0.03)***	0.0% (0.94)	25.0% (0.85)	12.6% **(0.024506)***
Dislocation (F)	13.2% **(0.03)***	9.3% (0.20)	4.8%	8.6% (0.58)	0.0% (0.94)	0.0% (0.69)	13.2% **(0.000839)***

Note: Values in brackets are *p*-values calculated with chi-square test in comparison with the most commonly used tube length. *p*-values < 0.05 are considered significant and marked with * and bold font.

Abbreviations: HC, healthcare staff; F, family.

TABLE 5 Complications reported, by healthcare staff and families, in relation to the gastrostomy tube thickness.

Complication	12 Fr *N* = 179	14 Fr *N* = 390	*p*-value
Granuloma (HC)	47.8%	67.4%	**<0.001***
Granuloma (F)	46.6%	65.8%	**<0.001***
Pain (HC)	23.6%	36.7%	**<0.001***
Pain (F)	10.8%	23.7%	**<0.001***
Leakage (HC)	19.1%	30.6%	**0.002***
Leakage (F)	15.9%	27.0%	**0.009***
Infection (HC)	10.7%	26.0%	**<0.001***
Infection (F)	12.5%	32.9%	**<0.001***
Dislocation (HC)	7.3%	8.8%	0.56
Dislocation (F)	7.4%	6.5%	0.86

Note: *p*-values are calculated with chi-square test and considered significant if < 0.05, and marked with * and bold font.

Abbreviations: F, family; HC, healthcare staff.

or if there is a risk for not completely dissolved medication to get stuck in the tube. Our recommendation is however debatable according to other authors who have reported an increased risk of dislodgement of 12 Fr gastrostomies compared to 14 Fr.[14] The findings in that study could not be confirmed in our material where the risk of dislodgement was lower, however not significantly, for patients with 12 Fr gastrostomies.

Patients receiving a tube with a length of additional 2 mm to the gastrostomy canal reported lower incidences of most of the complications. The distance of 2 mm above the skin seems to be not too tight and not to loose, and hence we suggest using a tube 2 mm longer than the gastrostomy canal. In a review comparing different types of paediatric gastrostomy devices and their complications, the authors note that a possible cause of granulation tissue could be a too long, or short, tube.[15] However, they did not propose any specific length that is shown to correlate with lower incidence of complications, and there seems to be a lack of knowledge in the literature on this topic. Hence, this need to be studied in a future prospective randomised study.

When comparing the operative techniques, our study cannot emphasise any method in favour of the others. Our study supports the idea that the technique should be chosen according to the surgeons' experience and suitability for the patient. This has been reported in previous studies, although some authors argue for different preferable operative techniques.[4,5,16–18]

The most common reason to receive a gastrostomy in our study was an underlying neurological disease. Comparing with mentioned group of patients, we could see that the oncologic patients reported lower incidence of granulomas, more postoperative pain and a higher rate of infections. These parameters probably coincide with the cytostatic treatment and an impaired ability to heal the gastrostomy stoma as well as neutropenic episodes. Higher incidence of postoperative infections among oncologic patients was

TABLE 6 Incidence of complications analysed with multivariable logistic regression.

	Granuloma OR (95% CI) *p*-value	Pain OR (95% CI) *p*-value	Leakage OR (95% CI) *p*-value	Infection OR (95% CI) *p*-value	Dislocation OR (95% CI) *p*-value
Tube thickness: 14 Fr (ref 12 Fr)	2.03 (1.14–3.63) **0.01***	2.79 (1.32–6.06) **0.008***	4.29 (2.15–8.78) **<0.001***	3.88 (1.93–8.05) **<0.001***	0.90 (0.25–2.97) 0.86
Tube length exceeding canal length: 0 mm (ref 2 mm)	0.91 (0.40–2.06) 0.81	1.00 (0.36–2.57) 0.10	1.20 (0.50–2.81) 0.68	1.99 (0.86–4.59) 0.10	3.97 (0.93–16.90) 0.06
Tube length exceeding canal length: 1 mm (ref 2 mm)	1.36 (0.68–2.77) 0.39	1.04 (0.46–2.26) 0.92	1.34 (0.63–2.79) 0.43	1.15 (0.55–2.35) 0.70	1.25 (0.26–4.66) 0.75
Tube length exceeding canal length: 3 mm (ref 2 mm)	6.36 (2.37–22.17) **<0.001***	1.42 (0.55–3.37) 0.446	1.58 (0.65–3.62) 0.292	1.76 (0.76–3.90) 0.173	2.18 (0.47–7.46) 0.255
Operation technique: Laparoscopic (ref open)	0.92 (0.41–2.04) 0.82	1.04 (0.40–3.30) 0.93	1.45 (0.57–4.22) 0.46	1.24 (0.49–3.61) 0.67	0.58 (0.17–2.71) 0.43
Operation technique: Push-PEG (ref open)	1.14 (0.45–2.88) 0.78	1.03 (0.35–3.49) 0.96	0.52 (0.18–1.66) 0.24	1.24 (0.45–3.85) 0.69	0.77 (0.16–4.56) 0.75
Age (0–215 months)	1.00 (0.99–1.01) 0.84	0.99 (0.97–1.00) **0.03***	1.00 (0.99–1.01) 0.61	1.00 (0.99–1.01) 0.64	0.99 (0.97–1.01) 0.39
Weight (1.5–84 kg)	1.00 (0.96–1.04) 0.88	1.07 (1.02–1.14) **0.02***	0.98 (0.93–1.02) 0.43	1.01 (0.97–1.05) 0.65	0.97 (0.84–1.06) 0.68

Note: The result is considered significant if the p-value < 0.05 and the CI does not encompass 1, and marked with * and bold font.
Abbreviations: CI, confidence interval; Fr, French; ref, reference; OR, odds ratio; PEG, percutaneous endoscopic gastrostomy.

also reported in a previous study.[4] Heavier patients reported more pain, and an explanation for that might be the difference in abdominal wall thickness and possibly increased soft tissue trauma during the operation.

We could not see any differences in the incidence of postoperative infections whether the patient received antibiotic prophylaxis or not. From our collected data, we cannot read out the timing of infections, and the group not receiving antibiotic prophylaxis included considerably fewer patients. Due to aforementioned factors, it is difficult to draw any conclusions. Our clinical experience is that very few of our patients are affected by infections short after the operation, and therefore, our interpretation of the results is that the postoperative infections during the first 3 months postoperatively cannot be prevented by antibiotic prophylaxis. Nevertheless, we do advocate antibiotic prophylaxis in consistency with previously published studies, which present reduction of postoperative infections and duration of hospital stay when used, something we did not investigate in our study.[19,20]

4.1 | Strengths and limitations

Strengths of this study are the prospective design and the large patient number which is uncommon in the field of paediatric surgery. Further, the separately filled in questionnaires, by healthcare staff and families, to some extent reduce bias. The Swedish population is provided with free healthcare as needed. Therefore, hesitation to seek care for complications, or a drop out from the study caused by socio-economical problems, seems unlikely.

Limitations of the study include the observational study design. Further, the techniques used for measuring the thickness of the abdominal wall differ between operative technique and may also differ between surgeons. Since the discrepancies between the lengths are also narrow, that adds on to the risk for inaccuracies. The different surgeons involved in the study may have had an impact on the outcome, as always regarding surgical procedures. However, we believe that the effect of the surgeon's experience is minimised in our study, since the inexperienced surgeons always were accompanied by a specialist in paediatric surgery and more complicated cases were operated by a senior paediatric surgeon.

Another limitation of the study is the difficulties in assessing pain. First, the healthcare staff meet the patient only during a short visit when the tube is supposed to be replaced, and not during the whole postoperative period. Also, the replacement procedure can cause both pain and fear, which can be difficult to distinguish between. Second, our patients are seldom able to report pain themselves, due to underlying health conditions or young age, and this

study therefore relies on the family's perception of pain during the postoperative period.

5 | CONCLUSIONS

In conclusion, this prospective observational study found that a gastrostomy tube with a thickness of 12 Fr and length of 2 mm longer than the gastrostomy canal, is associated with the lowest incidence of minor postoperative complications during the first 3 months after placement of gastrostomy. This applies to any indication for gastrostomy, choice of operative technique and regardless of age or weight of the child. Further randomised studies are needed to confirm these findings.

ACKNOWLEDGEMENTS

The authors thank all participating families and healthcare staff who enabled this study. We also thank Fabian Söderdahl, Statisticon for statistical analyses and Gillbergska foundation, H.R.H Crown Princess Lovisa's foundation for Scientific Research, and Fredrik and Ingrid Thuring's Foundation for funding.

FUNDING INFORMATION

This study was supported by unconditional grants from the Gillbergska Foundation (Uppsala, Sweden), HRH Crown Princess Lovisa's Foundation for Scientific Research, (Stockholm, Sweden) and Fredrik and Ingrid Thurings Foundation (Stockholm, Sweden).

CONFLICT OF INTEREST STATEMENT

Johan Danielson has received remuneration from the Viatris/Meda company (which is a supplier of gastrostomies) as a speaker at national meetings in Sweden. The other authors have no conflicts of interest relevant to this article to disclose.

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How to cite this article: Hössjer T, Göthberg G, Arnbjörnsson E, Rutqvist J, Perris F, Bartik Z, et al. Complication rate after gastrostomy placement in children can be reduced by simple surgical steps. Acta Paediatr. 2023;112:1597–1604. https://doi.org/10.1111/apa.16792