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Complications of Percutaneous and Surgical Gastrostomy Placements in Children: a Single-Centre Series

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ABSTRACT

Objectives: Gastrostomy placement is a standard procedure for children requiring enteral feeding for more than 3–6 weeks. Various techniques have been described (percutaneous endoscopic, laparoscopy, and laparotomy), and many complications have been reported. In our center, gastrostomy placement is performed either percutaneously by pediatric gastroenterologists, by laparoscopy/laparotomy by the visceral surgery team, or jointly, that is laparoscopic-assisted percutaneous endoscopic gastrostomy. This study aims to report all complications and identify risk factors and ways to prevent them.

Methods: This is a monocentric retrospective study including children younger than 18 years who underwent gastrostomy placement (percutaneous or surgical) between January 2012 and December 2020. Complications that occurred up to 1 year after placement were collected and classified according to their time of onset, degree of severity, and management. A univariate analysis was conducted to compare the groups and the occurrence of complications.

Results: We established a cohort of 124 children. Sixty-three (50.8%) presented a concomitant neurological disease. Fifty-nine patients (47.6%) underwent endoscopic placement, 59 (47.6%) surgical placement, and 6 (4.8%) laparoscopic-assisted percutaneous endoscopic gastrostomy. Two hundred and two complications were described, including 29 (14.4%) major and 173 (85.6%) minor. Abdominal wall abscess and cellulitis were reported 13 times. Patients who underwent surgical placement presented more complications (major and minor combined) with a statistically significant difference compared with the endoscopic technique. Patients with a concomitant neurological disease had significantly more early complications in the percutaneous group. Patients with malnutrition had significantly more major complications requiring endoscopic or surgical management.

Conclusion: This study highlights a significant number of major complications or complications requiring additional management under general anesthesia. Children with a concomitant neurological disease or malnutrition are at greater risk of severe and early complications. Infections remain a frequent complication, and prevention strategies should be reviewed.

What Is Known

- Minor complications are frequently observed after a surgical/endoscopic gastrostomy placement and frequently require only topical treatment.

What Is New

- Patients with malnutrition had significantly more major complications and complications requiring endoscopic or surgical management.
- Complications related to anchors are still rarely reported but could cause major complications. The ideal length of time the anchors should remain in place should be discussed.

INTRODUCTION

Enteral feeding can be administered through a nasogastric tube, nasojejunal tube, or digestive stoma (often a gastrostomy) (1–3). Placement of a gastrostomy has become a standard procedure that should be offered to children requiring enteral feeding for more than 3–6 weeks (4).

There are several techniques of gastrostomy placement: percutaneous under endoscopic or radiological control or surgical by laparoscopy or laparotomy. The percutaneous pull-type gastrostomy was first described in 1980 by Gauderer et al (5). However, this technique requires a second procedure under general anesthesia to replace the tube. Since then, several devices have been marketed to avoid this second interventional stage. The push or "direct puncture" technique involves fixing the stomach to the abdominal wall using sutures (gastropexy) and then introducing a balloon tube into the stomach under endoscopic or radiological control. Placement by laparoscopy has been described since the 1990s (6).

Numerous complications, most often minor, have been described with a frequency varying wildly in the literature (5%–50%) (7,8). The meta-analysis by Sandberg et al (9). reports a higher rate of major complications for percutaneous endoscopic gastrostomy (PEG) with an incidence of 5.4% compared with 1% for laparoscopic-assisted gastrostomy tube placement (LAP). Later, laparoscopic-assisted PEG (LA-PEG) presented a lower risk of intraoperative organ damage (8).

In our center, gastrostomies are placed either percutaneously by pediatric gastroenterologists or by laparoscopy/laparotomy by the visceral surgery team. Feeding is initiated as early as 3–6 hours postprocedure in stable children without difference between the two approaches, except in the case of multiple procedures (eg, fundoplication). Since 2019, we have been promoting, according to indications, joint placement, that is, a percutaneous endoscopic approach

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assisted by laparoscopy rather than isolated surgery. The joint technique allows gastropexy using anchors under visual control of the abdominal and intra-gastric cavity with, in some cases, minor traction on the stomach when misplaced in the abdominal cavity.

The objective of this retrospective monocentric study over 9 years is to report the complications (minor and major, early and late) encountered after a gastrostomy placement and to identify risk factors.

METHODS

Study Design

This is a single-center retrospective study including children who underwent a gastrostomy placement between January 2012 and December 2020 at the Hôpital Universitaire des Enfants Reine Fabiola. The local ethics committee approved it (CEH n°30/21). The gastrostomies were placed under general anesthesia with intubation either percutaneously under endoscopic control (using the push or pull technique), surgically (laparoscopy or laparotomy), or percutaneously under endoscopic control assisted by laparoscopy. All the gastrostomies placed in our center are 12fr or 14fr.

The cases were collected from the hospital's endoscopic and surgical archives. The exclusion criteria were placement in another center, age greater than 18 years, absence of endoscopy or surgery protocol, follow-up <6 months, and absence of follow-up data (follow-up in another center).

Data Collection

Data were collected from the patient's computerized medical record (Xperthis Care) and stored using an electronic data capture tool Research Electronic Data Capture (REDCap). For each child, the following data were collected: identification number, date of birth, sex, underlying disease, duration of enteral feeding by nasogastric tube, type of diet, presence of scoliosis and organomegaly, absolute contraindication to percutaneous insertion (uncorrected coagulation disorder or peritonitis), relative contraindications for PEG placement (previous abdominal surgery, kyphoscoliosis/spinal deformity, peritoneal dialysis, active gastritis/peptic ulcer, minor coagulation/bleeding disorders, gastric varices, portal hypertension, lack of clear identification of the stomach wall during endoscopy), preoperative examinations and abnormalities highlighted.

To identify malnourished patients, the weight and height before the procedure were recorded to calculate the BMI Z-score for children over 5 years old (severe denutrition <Z score –3/mild to low denutrition ≥Z score –3 and ≥Z score –2/no denutrition >Z score –2 and <Z score +1) and to calculate the Waterlow index for children of 5 years of age or younger (severe denutrition <70%/mild to low denutrition 70%–9%/no denutrition ≥90%) (10,11).

The insertion technique (PEG push or pull technique, LAP, gastrostomy by laparotomy, or LA-PEG), a change of intraoperative technique, concomitant surgery, intraoperative complications, length of hospitalization, and the number of days for total refeeding were recorded.

Postoperative complications were recorded and classified according to their time of onset as "early" (within 7 days), "intermediate" (beyond a week and up to 8 weeks), and "late" complications (beyond 8 weeks and up to 1 year). They were classified as minor or major according to the classification proposed by Hucl and Spicak(12).

The management of each complication was also listed and classified according to the Clavien-Dindo classification (13,14).

Finally, the persistence of anchors of gastropexy, posed by the push and LA-PEG techniques, was recorded on abdominal X-rays (when available) after 1 year or more.

Statistical analysis

Data were exported anonymously from REDCap and analyzed with SPSS version 27 and OpenEpi. Quantitative variables were described by their medians, interquartile ranges (IQR), and minimum and maximum values. Qualitative variables were expressed as frequency, percentage, odds ratio (OR), and 95% confidence interval (95% CI).

Complications were analyzed in 3 main groups: (1) all techniques combined, (2) endoscopic only, and (3) surgical only. A univariate analysis was carried out to compare the groups and the occurrence of complications (Pearson's chi-square—Fisher exact test if less than 5 cases per category). In each group, the rate of patients having had at least one complication (major or minor), at least one major complication, at least one early complication, and at least one complication requiring at least type II management according to the classification of Clavien-Dindo was calculated.

The analysis for possible risk factors focused on sex, age category (<1 year, 1–5 years, and >5 years), nutritional status (absence or presence of undernutrition), weight (<10kg or >10kg), the presence of concomitant neurological disease, and the placement technique. In addition, the history of abdominal surgery and associated surgical procedures during the gastrostomy placement were analyzed for the surgical group.

A P value less than 0.05 was considered statistically significant for all the tests.

RESULTS

Sample Description

Of the 152 children listed in the endoscopic and surgical archives for the period studied, 124 children met the inclusion criteria. Twenty-eight children had 1 or more exclusion criteria. They were not included in the analysis: 4 >18 years old, 13 had gastrostomy placement in another institution, 9 were followed for less than 6 months in our institution, and 2 did not have operative protocol available. Sixty-three (50.8%) were male. The median age at gastrostomy placement was 2.2 years (range, 0.01–16.7; IQR, 1.1–5.8). The distribution of concomitant diseases was as follows: neurological disease 50.8% (n = 63), digestive disease 10.5% (n = 13), respiratory disease 10.5% (n = 13), renal disease 8.1% (n = 10), ear, nose and throat abnormality 7.3% (n = 9), metabolic disease 7.3% (n = 9), isolated food aversion (without syndromic or malformation context) 4.8% (n = 6), and cardiac disease 0.8% (n = 1).

Ninety-eight children (79.7%) were already fed by nasogastric tube. Feeding was exclusive in 45 (45.9%) children and supplemented by oral feeding in 53 (54.1%) children. Administration of enteral nutrition was continuous in 19 (19.4%) children and bolus in 79 (80.6%). Thirty-five (35.7%) received infant formula, 28 (28.6%) toddler milk, 10 (10.2%) hydrolyzed formula, 9 (9.2%) an amino acid-based formula, and 13 (13.2%) a specific diet (in some instances of metabolic, pulmonary, or renal pathology). Data were missing for 3 patients (3.1%). The median duration of enteral feeding by nasogastric tube before the placement of the gastrostomy is 8 months (range, 0–72; IQR, 4.75–14).

Nineteen (15.3%) children had scoliosis, and 7 (5.7%) had hepatomegaly and splenomegaly. Twenty-three (18.6%) had a history of digestive surgery (appendectomy, treatment of intestinal malrotation, diaphragmatic hernia repair, or pyloromyotomy). One hundred and seventeen (94.4%) underwent 1 or more additional examination(s) preoperatively, including gastroscopy, pH-impedancemetry, and oeso-gastro-duodenal transit. Twenty-nine (23.4%) had gastroesophageal acid reflux, 9 (7.3%) had gastroparesis, 12 (9.7%) had peptic esophagitis, and 16 (12.9%) had an anatomical

variant preventing placement percutaneously. None of the children had an absolute contraindication to percutaneous insertion (uncorrected coagulation disorder or peritonitis), while 35 had a relative contraindication (16 [12.9%] organ interpositions, 14 [11.4%] history of digestive surgery, and 5 [4.1%] peritoneal dialysis catheters).

The median preoperative weight was 10.6 kg (range, 2.28–39.1; IQR, 7.7–14.6). Sixty-seven (54%) children had normal nutritional status, 38 (30.7%) had mild to moderate malnutrition, and 11 (8.9%) had severe malnutrition. Data were missing for 8 (6.4%) patients.

Placement Technique

PEG was performed in 59 patients (47.6%), including 17 (13.7%) pull technique and 42 (33.9%) push. Fifty-nine patients (47.6%) underwent surgical placement, including 44 (35.5%) LAP and 15 (12.1%) by laparotomy. LA-PEG. The distribution is homogeneous between these groups regarding sex, concomitant pathology, and nutritional status. Thirty-five (28.2%) patients underwent another surgical procedure during the same anesthesia, including 21 fundoplications.

Three patients (2.4%) required a change of technique intraoperatively: (1) endoscopy to laparoscopy due to the presence of oesophageal stricture in a context of epidermolysis bullosa, (2) endoscopy to laparotomy following interposition of the omentum and a high placed stomach in a patient with a polymalformative syndrome, (3) laparoscopy towards laparotomy following numerous adhesions in a patient operated on for a right diaphragmatic hernia.

The median length of hospitalization is 7 days (range, 2–321 days; IQR, 5–10). Ninety-six (77.4%) children were fully fed in 3 days (range, 2–24; IQR, 3) and 21 (16.9%) after 3 days. Data are missing for 7 (5.7%) children.

Complications

Intraoperatively, 1 complication was reported during the placement of a gastrostomy by laparoscopy associated with a cure of malrotation and a fundoplication. It was a low cardiac output that required cardiopulmonary resuscitation.

Only 18 patients did not have any complications. Forty-seven had 1 complication, 48 had 2, and 8 had 3 or more complications. In addition, there were several patients presenting multiple minor complications.

The total number of complications recorded was 202: 25 (12.4%) early, 77 (38.1%) intermediate, and 100 (49.5%) late complications. Twenty-nine (14.4%) were major (13 infections, 2 aspiration pneumonia, 6 gastric obstructions, 1 prolonged ileus, 1 intraabdominal bleeding, 1 gastric perforation, 3 dehiscences, 1 gastrocolic fistula, and 1 gastro-cutaneous fistula) and 173 (85.6%) minor complications (Table 1). For major complications, 7 (24.1%) occurred early, 9 (31.1%) during the intermediate period, and 13 (44.8%) were late. Of the 173 minor complications, 18 occurred early, 68 during the intermediate period, and 87 late (Fig. 1).

TABLE 1. Major and minor complications

		n	%
Major	Abdominal wall abscess or cellulitis	13	6.4
	Aspiration pneumonia	2	1
	Gastric obstruction	6	3
	Prolonged Ileus	1	0.5
	Intraabdominal bleeding	1	0.5
	Gastric perforation	1	0.5
	Dehiscence	3	1.5
	Gastrocolic fistula	1	0.5
	Gastro-cutaneous fistula	1	0.5
Minor	Granulation tissue formation	58	28.7
	Local infection	33	16.3
	Skin erythema	12	5.9
	External fluid leaks	16	7.9
	Accidental tube removal	31	15.4
	Tube damage	13	6.4
	Tube obstruction	4	2
	Internalizations of the anchor	2	1
	Bleeding around anchor	1	0.5
	Tube migration	1	0.5
	Gastric wall ulceration	1	0.5
	Cutaneous fistula (< anchor)	1	0.5
Total		202	100

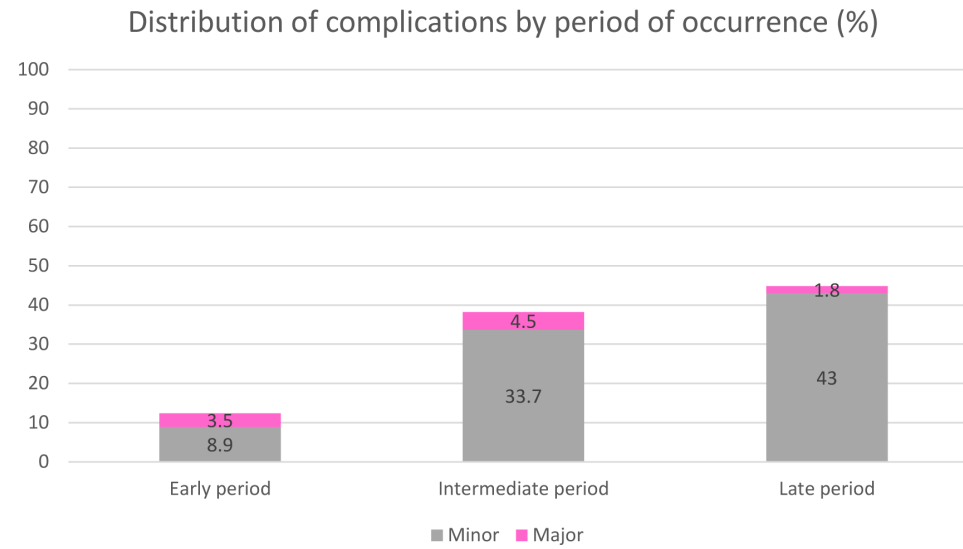

FIGURE 1. Distribution of complications by period of occurrence (%).

Complications required "local" management on 154 occasions (type I of the Clavien-Dindo classification—76.2%) and corresponded to the pause of enteral feeding, change of the gastrostomy button, unblocking of the tube, local care (local antibiotic therapy included). Drug treatment (systemic antibiotic therapy) was prescribed 25 times (Type II of the Clavien-Dindo classification—12.4%). Endoscopic, radiological, or surgical management requiring general anesthesia is reported 21 times (Type IIIb of the Clavien-Dindo classification—10.4%). Type V corresponded to patient death and was reported once. Types IIIa and IV have not been reported (see Fig. 2).

Rehospitalization for managing a complication was necessary in 10.7% of cases (19/177, N = total of intermediate and late complications).

In the group comparing all 3 procedures, there was no significant difference in the occurrence of complications according to sex, age, nutritional status, weight, and the presence of neurological disease. Patients who underwent surgical placement presented more complications (major and minor combined) with a statistically significant difference compared to the endoscopic technique (Fig. 3A). This difference was not significant in the analysis of the other categories.

In the endoscopic group, patients with concomitant neurological disease had significantly more early complications (25.8 vs. 3.6%; OR, 9.1; 95% CI, 1.09–0; $P = 0.01$) (Fig. 3B). However, there was no significant difference in the occurrence of complications according to the other factors studied (type of endoscopic pull/push technique included).

In the surgical group, patients with undernutrition had significantly more major complications (12.1% vs. 40%; OR, 4.7; 95% CI, 1.2–18; $P = 0.01$) and more complications requiring at least grade II treatment according to the Clavien-Dindo classification (21.2% vs. 55%; OR, 4.4; 95% CI, 1.3–15.7; $P = 0.01$) (Fig. 3C). There was no significant difference in complications regarding the other factors studied (including in the event of associated surgery or with a history of abdominal surgery).

Of the 48 children who had gastropexy with anchors, half had a chest/abdomen X-ray within 6 months to 1 year, and 10 (42%) still had 1 or more anchors. Seven had 1 or more X-ray(s) in the following years, and all still show 1 or more anchor(s). One patient presented a major complication (gastrocutaneous fistula) following the internalization of the anchor in the gastric wall.

DISCUSSION

The studied population included 50% of children with neurological impairment causing swallowing disorders that lead to aspiration or poor intake and agrees with the literature regarding the main profile of patients (35%–60% of the sample) requiring placement of a gastrostomy (7,8,15).

The median duration of enteral feeding by nasogastric tube before the gastrostomy placement in our study is 8 months. According to guidelines, the placement of a gastrostomy must generally be proposed when enteral nutritional support is required for more than 3–6 weeks (1). Caregivers'decision for referral to a gastro-enterologist/surgeon, the parent's delay in accepting the gastrostomy placement, the child's clinical condition, and the time needed to access the surgical program may explain this difference.

A case of gastric perforation was reported on day 8 postoperatively following laparoscopic gastrostomy placement associated with fundoplication. It is presented by leakages caused by poor approximation of the stomach to the abdominal wall, leading to chemical peritonitis. No other cases of intraoperative organ perforation were reported here. The systematic review and meta-analysis by Baker et al (4)., including 6 studies comparing the laparoscopic technique (N = 521) to the endoscopic technique (N = 361), reports an intraoperative organ lesion rate of 0.06% (0%–0.96%) versus 1.72% (0%–12.2%), respectively.

This study highlights at least 1 complication (regardless of severity) in 106 (85.5%) patients and reports a significantly lower complication rate in the PEG group compared to the surgical group (laparoscopy and laparotomy) (OR, 0.3; 95% CI, 0.07–0.9) ($P = 0.001$). The study by Liu et al (16). does not show any significant difference when it compares the PEG group to the LAP group (54.7%–44.6%) ($P = 0.135$). The rate of minor complications highlighted in this study agrees with the literature regarding their widespread appearance (9) and the generally similar rate regardless of the technique (LAP or PEG) (16,17).

Although a single prophylactic antibiotic therapy with cefazolin is systematically administered before each procedure, the rate of infectious complications remains high: 13 cases of abdominal wall abscess or cellulitis (6.4% of total complications) and 33 cases of minor infection (16.3% of total complications) requiring local treatment. It is essential to raise awareness among caregivers and parents to prevent these infections. Rigorous intraoperative asepsis is

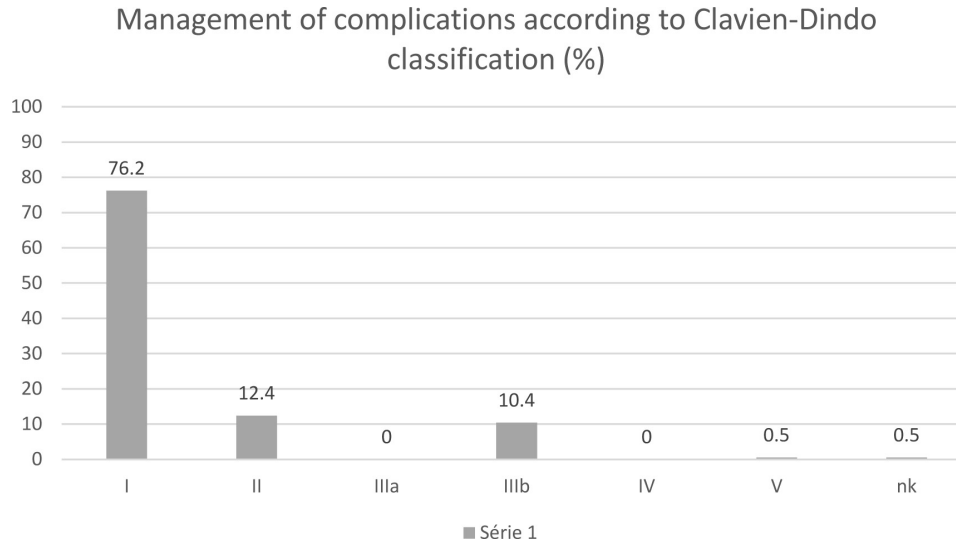

FIGURE 2. Management of complications according to Clavien-Dindo classification (%).

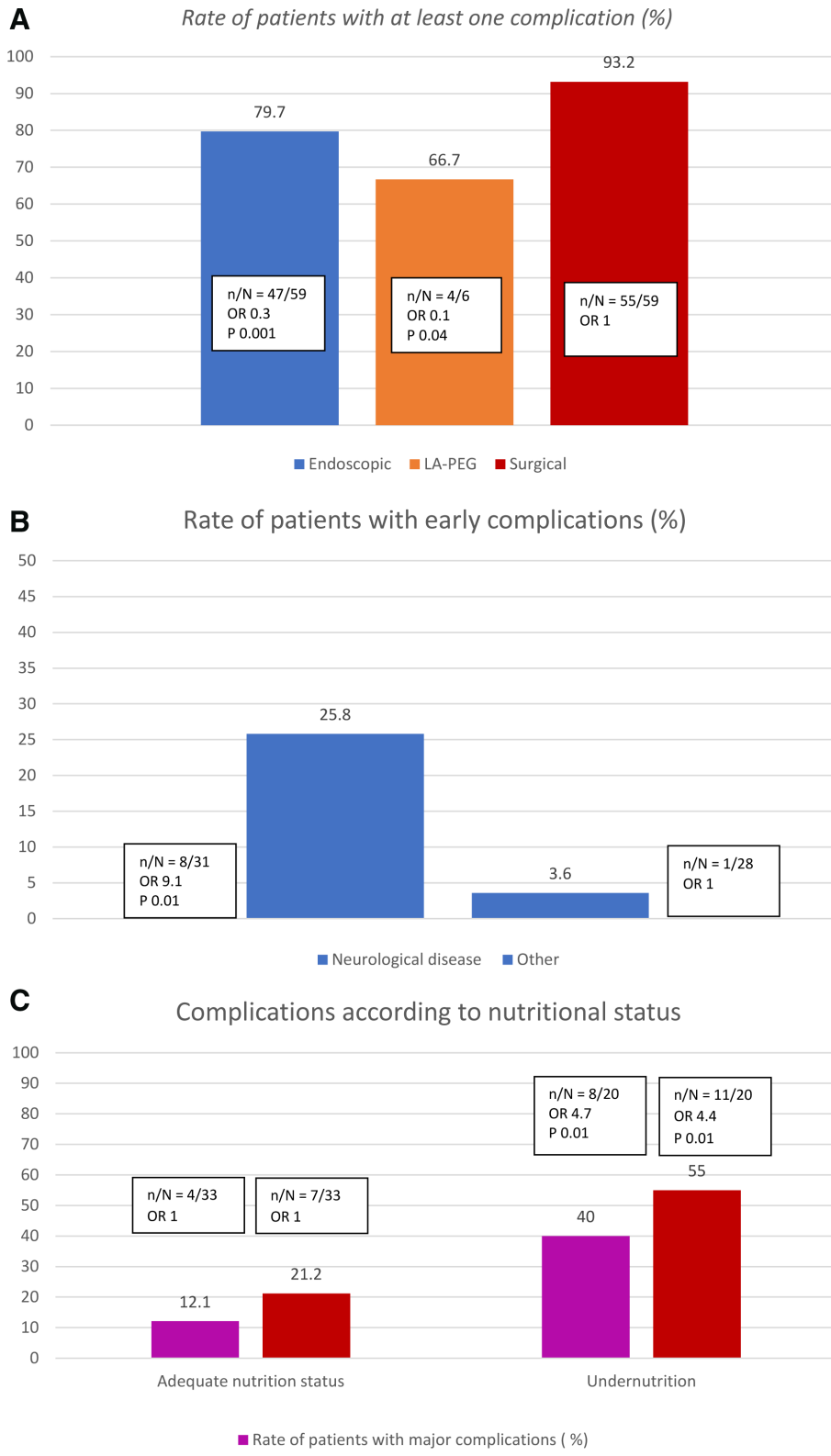

FIGURE 3. Analysis of complication's occurrence according to various factors—statistically significant results. Odds ratio value of 1 was arbitrarily attributed to the group to which the others were compared. **3a**. All techniques combined: total of patients = 124; **3b**. PEG: total of patients = 59, **3c**. surgical gastrostomy: total of patients = 59. N = total number of patients per category. n = number of patients with the factor and the studied complication; PEG = percutaneous endoscopic gastrostomy.

required, and postoperative care must be rigorous and well-explained to parents/caregivers.

The gastric obstruction was related to the gastrostomy placement in the antrum, with the balloon obstructing the pylorus using the surgical technique in patients with scoliosis or prior abdominal surgery or organomegaly. However, given the small number of subjects, no safe conclusions can be drawn.

This study reports at least 1 major complication in 19.4% of the population studied (24/124) with no significant difference according to the technique used (PEG 15%) (OR, 0.5; 95% CI, 0.2–1.5; P = ns), surgery 23.7% (OR, 1—arbitrarily assigned for the control group), LA-PEG 16.7% (OR, 0.6; 95% CI, 0.1–6; P = ns). The major complication rate reported in the literature ranges from 0.6% to 17.5% for PEG versus 0%–3.8% for LAP, but the definition of major complication differs between studies (6–9,16–19). Sandberg et al (9)., defines a major complication as a complication occurring within 30 days postop requiring urgent management by surgery/endoscopy (from type III of the Clavien-Dindo classification), reports in its meta-analysis (8 studies, N = 1550 patients) a rate of major complications of 3.6% (PEG 5.4% >< LAP 1%) with an OR of 3.86 (95% CI, 1.90–7.81; $P < 0.0002$) occurrence of major complications in the PEG group compared to the LAP group. Our rate of major complications is higher than Sandberg et al (9) but the definition of major complications is based on another classification (12). If the same classification criteria of the major complication of Sandberg et al (9) are applied to our study, the rate of patients with a major complication is 4.8% (PEG 1.7% >< LAP 8.5%) with OR, 0.2 (95% CI, 0.004–2.5; $P = 0.2$) of major complications for PEG insertions compared to surgery.

Baker et al (4). report, like Sanderg et al (9)., an advantage of the laparoscopic technique compared to the endoscopy technique in terms of major complication (OR, 0.29; 95% CI, 0.17–0.51; $P = 0.0001$). Several other studies (9,20,21) show similar results and explain that the LAP makes it possible to directly visualize the peritoneal cavity during the puncture (instead of a blind puncture in the case of PEG), thus avoiding injury to an organ such as the liver or the colon. Our observations do not go in the same direction as the authors quoted above.

Almost 17% of the study population had an early complication with no observed difference between techniques. Comparison with other studies is difficult because the definition of early complication differs between them (48 hours, 7 days, 14 days, or 30 days postoperative). Liu et al (16) report a higher early complication rate (within 14 days) in the PEG group compared to the LAP group but a comparable late complication rate (which represents most complications) between the 2 techniques.

Patients with a neurological impairment who received PEG showed significantly more early complications. In the literature, the results diverge to a higher rate of complications in patients with neurological impairment. Fortunato et al (22). report an increased risk of complications in patients with underlying neurological disease. For McSweeney et al (23), young age (<6 months), a weight <4 kg, an American Society of Anaesthesiologists class III score, and an underlying neurological pathology would have a "protective" effect against major complications because those patients are monitored more closely. The study published by Balogh et al (8). considers that for the placement of percutaneous endoscopic gastrostomy, hepatomegaly, coagulopathy, oesophageal stenosis, and peritoneal dialysis are possible risk factors, whereas constipation, history of abdominal surgery, neurological involvement, age <1 year, and scoliosis are not.

The undernourished patients in the surgical placement group (laparoscopy/laparotomy) presented more major complications ($P = 0.01$) and required more invasive management (>type II of the Clavien-Dindo classification [$P = 0.01$]). Szlagatys-Sidorkiewicz et al (24) report in a multicentre analysis that younger children have a lower prevalence of undernutrition and have, therefore, fewer postoperative complications.

Finally, 1 of the major complications reported is caused by a gastropexy anchor that internalized in the gastric wall and caused a gastro-cutaneous fistula that required surgical treatment. Data from the literature diverge on the complications caused by this device in children. Göthberg et al (N = 201) and Jacob et al (N = 186) report none (25,26). Livingston et al. (N = 93) report 3 (1 requiring endoscopic evaluation and 2 extracted under local anesthesia) (27). Kvello et al. (N = 86) report 13% for his population (migration of the anchor in the gastric or abdominal wall), of which 45% required removal under general anesthesia (28). Some blame the sutures being cut too late (3–5 weeks postoperative) and recommend doing so within 2–3 weeks (25,27,29).

The limitations of this study are the retrospective data collection, the small number of patients in certain groups not allowing a multivariate analysis, and the lack of hindsight on the percutaneous endoscopic technique assisted by laparoscopy practiced only recently within our institution. Patients lost to follow-up and patients for whom the gastrostomy was placed in another institution were excluded. They constituted a selection bias, as well as patients with contraindications to the endoscopic placement who required surgical gastrostomy. Some minor infectious complications could probably be treated in the community (over-the-counter medication) and were not reported. This perhaps underestimates the total number of minor complications. Finally, comparison with literature data is not easy because there is no consensus on the definitions of major, minor, early, and late complications. The strengths of this study are an exhaustive collection of detailed data permitting a precise analysis of complications. It allowed us to identify conditions at risk of more severe complications and, therefore, helped to improve our practice and the quality of patient care.

In conclusion, this study highlights a significant number of major complications or complications requiring additional management under general anesthesia after the placement of a gastrostomy in children. Infections remain a frequent complication, and prevention strategies should be reviewed. Children with a concomitant neurological disease or malnutrition are at greater risk of severe and early complications. Minor complications, highly prevalent in this study, usually require only topical treatment.

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