



# Evaluation of minimally invasive percutaneous gastrostomy with Nissen fundoplication versus open surgery in children with infantile cerebral palsy

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## Abstract

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**Introduction:** Children with infantile cerebral palsy (ICP) have severe nutritional disorders due to gastrointestinal symptoms such as gastroesophageal reflux (GER). The objective of the present study was to compare minimally invasive percutaneous gastrostomy techniques with Nissen Funduplicature (MI-NF) versus open surgery (OS-NF) for the treatment of gastroesophageal reflux and swallowing disorders in children with child brain paralysis.

**Methodology:** This observational study with nonprobabilistic sampling included children with ICP swallowing disorders and GER at the Dr. Roberto Gilbert Elizalde Children's Hospital in Guayaquil-Ecuador from 2017 to 2022. Age, type of surgery, complications, feeding start time, symptoms, and comorbidities. A descriptive analysis is performed. A second analysis compared patients treated with MI-NF + percutaneous gastrostomy versus OS-NF + Stamm-type gastrostomy.

**Results:** Sixty-two patients were included: 40 men (64.5%), 39 patients <3 years old (62.9%); 27 patients with severe malnutrition (61.4%); 13 patients (29.5%) who were admitted for an episode of pneumonia; 52 patients with OS-NF; and 10 with MI-NF. The start of feeding at 48 hours in the MI-NF group was 8 cases (80%); in OS-NF, 3 cases (5.8%)  $P < 0.0001$ . There were no differences in age or complications between the groups.

**Conclusion:** With the technique of percutaneous gastrostomy with MI-NF, there was a minimum time when the patients started feeding through the gastrostomy tube.

## Keywords:

**MESH:** Child; Gastrostomy; Fundoplication; Esophagitis, Peptic; Laparoscopy; Cerebral palsy.

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## Introduction

The gastroesophageal reflux-associated disease is a condition present when the reflux of stomach contents causes complications and bothersome symptoms [1]; a condition in which gastric contents reflux into the esophagus or beyond; its diagnosis can be established with symptoms, pathological studies, or physiological studies [2].

On the other hand, it is suggested that infantile cerebral palsy (ICP) is associated with brain diseases with skeletal muscle alterations [3], leading to multiple disorders, leading to the inability to generate movements, including intestinal peristalsis [4].

In Ecuador, since there is little research associating infantile cerebral palsy and gastroesophageal reflux, there is an urgent need to study this association since it constitutes one of the causes of consultation and admission to pediatric intensive care units [4], which can lead to neonatal age, the manifestation of episodes of cyanosis, apnea, pneumonia and other complications that can cause the death of the child [5].

Knowing that the prevalence of gastroesophageal reflux symptoms is high and its clinical characteristics continue to be investigated around the world [6], this problem is given great attention in the pediatric population since in their anatomy, physiology, and pharmacology, children, especially the smallest ones, differ from adults [7]. As the most widely used surgical procedure in cases of gastroesophageal reflux in the pediatric population, Nissen fundoplication has been a safe and highly effective technique, which is why it is considered the technique of choice [8-10].

The feasibility of the approach with this therapeutic option is appreciated, which allows the achievement of results that contribute to the improvement of the quality of life of children with ICP, for which the objective of the present study was to compare the techniques of percutaneous gastrostomy with Fundoplication of Nissen minimally invasive versus open surgery for treatment of gastroesophageal reflux and swallowing disorders in children with infantile cerebral palsy.

## Methodology

### Design of the investigation

This trial is an observational, relational, retrospective study.

### Scenery

The study was carried out in the pediatric surgery department of the "Dr. Roberto Gilbert Elizalde" Children's Hospital in Guayaquil-Ecuador. The study period was from January 1, 2017, to February 1, 2022.

### Inclusion criteria

Hospitalized pediatric patients diagnosed with swallowing disorders and gastroesophageal reflux entered the study. The international classification of diseases tenth edition (ICD-10) codes were used for the research: K21.0 and R13. Incomplete records were excluded from the analysis.

### Studio size

The universe was patients admitted to the institution. The sampling was nonprobabilistic for convenience, and all possible cases were included in the study period.

### Variables

The variables were dependent: type of surgery; group 1: laparoscopic Nissen fundoplication + percutaneous gastrostomy; group 2: open Nissen fundoplication + Stamm gastrostomy. Independent variables: sex, age group, complications, initiation of gastrostomy tube feeding, digestive symptoms, and comorbidities.

### Data sources/measurement

The data were collected in a specific electronic form for this purpose. The hospital's electronic system of clinical records was used to investigate cases.

### Surgical procedure

#### Laparoscopic Nissen fundoplication:

The intervention required the introduction of four 5-mm trocars (1 optic and three forceps).

- A first 5-mm trocar is placed at the umbilical level using the Hasson technique, a 5-mm 30 optical chamber is inserted, and it is inflated with a CO<sub>2</sub> pressure of 8 to 12 mmHg and a flow of 5 to 10 L/min. Under direct vision, three more trocars are placed: right subcostal, epigastric, and left or middle supraumbilical.
- A clamp is inserted through the right subcostal port to lift the left lobe of the liver and expose the hiatus.
- The gastrosplenic ligament and short gastric vessels are dissected up to the left pillar of the diaphragm, continuing to section the gastrohepatic ligament up to the right pillar of the diaphragm.

- The retro-esophageal space inferior to the diaphragmatic pillar and superior to the left gastric veins is opened, allowing the esophagus to be quickly mobilized and the gastroesophageal junction located within the abdominal cavity.
- Stitches are placed between the esophagus and the pillars at the 3 and 9 o'clock positions clockwise to help maintain the esophagus in its intra-abdominal position.
- The 360° wrap of the fundus begins with a shoe-shine maneuver and ends with three silk sutures (incorporating fundus-esophagus-fundus) to the cuff (approximate distance of 2 to 3 cm).
- To make the cuff, the surgeon places an intraesophageal stent, especially in older patients (weighing more than 5 kg); in other cases, the wrapping is made around a 14 Fr suction catheter.

### Percutaneous Gastrostomy

- The "pull" method was used, which consists of the following steps:
  - The patient is in a supine position on the endoscopy table, a mouth retractor (self-retainer) is placed to avoid endoscope injuries, and the gastrostomy kit is assembled on the surgical table.
  - The gastroscope is inserted and passed into the stomach, the fully inflated stomach and duodenum are inspected, and the gastroscope is positioned just proximal to the gastric flexure.
  - The assistant observes the abdominal wall, looking for an area of transillumination; this point indicates the site where the stomach and abdominal wall are in close contact with no intervening tissue, and finger pressure at this site will cause a definite indentation in the gastric wall, as seen by the endoscopist.
  - A 1 cm long incision is made in the skin. The 16 French gauge intravenous cannula, with an external sheath, is pushed through the abdominal walls, the lasso is passed, the trap is tightened around the cannula, and the needle is withdrawn from the cannula, leaving only the sheath at the puncture site.
  - A 60-inch long #2 nylon or silk suture is passed through the cannula into the stomach. When several centimeters have passed into the stomach, the trap is loosened and allowed to slide toward the suture; the trap is then retightened, and the suture is lifted through the esophagus and out of the patient's mouth. The

gastrostomy tube is placed, and the assistant begins the pull at the abdominal end of the suture and then passes retrograde into the esophagus, stomach, and out of the abdomen after several centimeters of the tube has exited the abdominal wall.

- The gastroscope is inserted once more, and the head of the gastrostomy tube is identified. The endoscopist instructed the assistant to continue pulling the tube's abdominal end until the tube's head met the gastric mucosa, and the plate of the gastrostomy tube was placed, which provided fixation to the abdominal wall until firm adhesion occurred.

### Open Nissen fundoplication

- With the patient lying on the surgical table in the supine position.
  - A suprmedian umbilical incision is made, divulged by planes until reaching the abdominal cavity; with a moistened compress, the transverse colon is lowered, exposing the liver and stomach.
  - The gastrohepatic ligament is identified, which is released until the quadrate lobe can be properly mobilized; the esophagus is observed, and the vascular part of the gastrophrenic ligament is identified, which spreads until it can pass through the posterior face of the esophagus; an umbilical tape is passed to betray the esophagus.
  - The stomach fundus is identified and positioned below the esophagus, turning 360 degrees, placing a suture point with 2.0 silk holding the fundus of the stomach and the anterior face of the esophagus and the other end of the fundus of the esophagus.
  - A 14 Fr aspiration probe is passed to check patency and good fundoplication preparation.

### Stamm-type gastrostomy

- A supraumbilical median incision is made; a segment of the greater curvature, close to the fundus, is removed by atraumatic traction through the incision. In its avascular part, we make an internal purse in a clockwise direction and then an external purse in a counterclockwise direction.
  - We affect the center of the internal drawstring until we reach the stomach lumen
  - An incision is made in the skin; in contrast, opening, we introduce a gastrostomy tube with a 20 or 14 Fr balloon, and the balloon is inflated.

- Four fixation points are placed: two posterior and two anterior, in the direction of the cardinal points, joining the anterior face of the stomach to the peritoneal or abdominal wall.

### Bias avoidance

Every effort was made to avoid the following possible biases in the study: Selection bias (Nonresponse bias, membership bias, selection procedure bias, loss-to-follow-up bias); Measurement bias (recall bias, procedural bias, instrument insensitivity bias, detection bias, accommodation bias, attention bias, interviewer bias, obsequiousness bias), which a supervisor and a research tutor controlled for presented as roles in the contributions of the authors.

### Statistical method

The data analysis is univariate and descriptive with frequencies and percentages. A second bivariate analysis compares the results of the group of patients treated through laparoscopic Nissen fundoplication + percutaneous gastrostomy versus open Nissen fundoplication + Stamm-type gastrostomy. A comparison of proportions with Chi<sup>2</sup> is used. The statistical package SPSS v.23 (NY: IBM Corp.) was used for the analysis.

## Results

Sixty-two patients were analyzed. The descriptive analysis is presented in Table 1; there were 40 men (64.5%) within the age groups, with those under three years of age having the highest percentage, with 39 patients at 62.9%. The open surgery modality was performed in 52 patients (83.9%). A total of 7 patients (11.3%) presented a granuloma at the gastrostomy site, 5 (8.1%) developed an infection associated with the puncture site, and the rest did not present complications.

Feeding through the gastrostomy tube was started in 42 patients (67.8%) between 3 and 5 days. The digestive symptoms presented were regurgitation in 44 patients (71%) and dysphagia in 18 cases (29%). The comorbidities present were severe malnutrition in 43 cases (69.4%), pneumonia in 13 (21%), and hydromicrocephaly in 6 patients (9.7%).

### Bivariate analysis

Fifty-two patients underwent open surgery, and ten underwent minimally invasive surgery. There was no age difference between patients undergoing open surgery vs. minimally invasive surgery. Feeding initiation was faster in the minimally invasive surgery group. In the present study, 80% of the patients who underwent minimally invasive surgery began feeding through the gastrostomy tube before 48 hours, and the most significant number of children who underwent open surgery, 78.8%, took between 3 and 5 days.

There were no differences in complications between the two study groups (Table 2) or the presence of granulomas or infections.

According to the presented symptoms of regurgitation (n=44) and dysphagia (n=18), there were significant differences regarding the presence of hydromicrocephaly, severe malnutrition, and pneumonia as predisposing factors (Table 3).

**Table 1.** General characteristics of the study group.

	Frequency	Percentage
Sex		
Feminine	22	35.5%
Male	40	64.5%
Age		
< 3 years	39	62.9%
4 to 7 years	8	12.9%
>7 years	fifteen	24.2%
Type of surgery		
Open	52	83.9%
Minimally invasive	10	16.1%
complications		
None	fifty	80.6%
Granuloma in gastrostomy	7	11.3%
Infection	5	8.1%
Start gastrostomy tube feeding		
Up to 2 days	eleven	17.7%
3 – 5 days	42	67.8%
6 – 7 days	9	14.5%
digestive symptoms		
Regurgitation	44	71.0%
Dysphagia	18	29.0%
Comorbidities		
Hydro microcephaly	6	9.7%
Severe malnutrition	43	69.4%
Pneumonia	13	21.0%

**Table 2.** Age, time of initiation of feeding, and complications in the study groups.

Variable	Open surgery-NF N=52	Minimal invasive surgery-NF N=10	P
Age			
Under 3 years	35 (71.3%)	4 (40%)	0.260
4 to 7 years old	6 (11.5%)	2 (20%)	
Older than eight years of age	11 (21.2%)	4 (40%)	
Start of feeding			
Up to 2 days	3 (5.8%)	8 (80%)	<0.0001
3 -5 days	41 (78.8%)	1 (10%)	
6 -7 days	8 (15.4%)	1 (10%)	
Complications			
None	41 (78.8%)	9 (90%)	0.465
Gastrostomy granuloma	7 (13.5%)	0 (0%)	
Infection	4 (7.7%)	1 (10%)	

NF: Nissen fundoplication

**Table 3.** Variables according to symptoms after surgery.

Variable	Regurgitation N=44	Dysphagia N=18	P
Age			
Hydro microcephaly	4 (9.1%)	2 (11.1%)	0.034
Severe malnutrition	27 (61.4%)	16 (88.9%)	
Pneumonia	13 (29.5%)	0 (0%)	

## Discussion

The main finding of this study is that the start of feeding can be accelerated with the placement of gastrostomy with minimally invasive surgery, with no difference in the presence of complications associated with the procedure compared to open surgery in a group of children with infantile cerebral palsy. With the development of multiple swallowing problems in children with ICP, severe malnutrition is expected, for which nutritional support, gastroenteric tube placement, and antireflux surgery are necessary. Studies that analyze and relate the problems of swallowing disorders and infantile cerebral palsy are essential, especially if one considers introducing new surgical procedures in a less invasive and promising future [12- 14]. ICP has an incidence of 2-3 cases per 1,000 live births [11-14]. In underdeveloped countries, it has been considered the cause of the highest frequency of motor disability in the pediatric population, and as a pathology, it has various classifications, which relate brain involvement, as well as the degree of injury. Concerning the clinical

aspect, factors such as the extension and location of the lesion and the level of alteration of functionality, among others, influence [15]. Since ICP is a disabling condition, the most common in pediatric patients [16], its frequent occurrence is accompanied by various comorbidities, which affect the expectation of an excellent vital prognosis and even hinder the rehabilitation process. These antecedents concern health professionals due to eating disorders; therefore, with the present study, the opinion is reaffirmed that the impairment of the quality of life of patients with ICP is associated with the pathological condition of reflux gastroesophageal as a source of morbidity and mortality [17-18], and this can be reduced with minimally invasive antireflux surgery.

In the results obtained, it is observed that motor involvement is considered a severe problem in the clinical picture of patients with ICP. Although these may vary depending on the affected body part, the presence of recurrent respiratory symptoms, extrapyramidal signs, spasticity, and malnutrition, among others, promote the search for surgical alternatives through these antireflux operations. According to Peláez et al. (2021), reflux problems are observed in between 50% and 75% of patients with ICP. Since its etiology is multifactorial, suspicion will be considered in the presence of symptoms such as vomiting, respiratory complications, rejection of ingestion, hypersalivation, or others [19].

The study carried out by Bravo (2021) recognizes that respiratory complications are the most important in patients with ICP, although those that occur in other systems cannot be underestimated. In this study, it is recommended that gastrostomy be used to improve these complications, also contributing to weight gain in children. In this retrospective investigation, the procedure did not influence the reduction of admissions, and no advantages were observed in the prevention of complications due to pneumonia [20].

The field of laparoscopic surgery has experienced exponential growth [21-23], with a high level of success in patients with reflux, rapid recovery, and a decrease in complications associated with surgery. Mainly in patients with ICP, laparoscopy has a particular application due to the prompt recovery, the shorter exposure time to anesthetics and the reduction of unfavorable events.

In children with ICP, the presence of so-called "gagging" is a frequent symptom, which is the violent movement of the stomach that occurs before vomiting or during vomiting; particularly in those patients with neurological disabilities, gagging becomes one of the leading causes of sheath ruptures. This component of the emetic reflex is also indicative of the presence of nausea [24-25], a constant discomfort associated with reflux that can be controlled with surgery.

In this study, no statistical association was observed between comorbidities and digestive symptoms; however, it is known that the more severe and more intense the neurological damage, the more digestive symptoms also increase, as well as the degree of malnutrition [26] and the presence of infections. The symptoms that explain the nutritional deterioration in patients with neurological disabilities are associated with motor alterations, dysmotility of the esophagus, paralysis of the swallowing muscles, and delayed gastric emptying [26]. This constant feeding difficulty leads to severe malnutrition; however, repeated episodes of pneumonia come from bronchial aspiration [27]. To improve the condition, patients receive surgical antireflux treatment, given the severity of gastroesophageal reflux as a disease. These problems with swallowing in patients with ICP are explained as a complex neurological mechanism, beginning with the difficulty they have in controlling their tongue and then moving on to the movement of the food bolus from the mouth to the pharynx delays swallowing. [4].

Surgical treatment of gastroesophageal reflux by laparoscopy has been successfully managed in Latin America. Several works have demonstrated this, and they conclude that the laparoscopic approach for the treatment of this pathology in the pediatric population significantly reduces intra-abdominal complications, being a procedure that offers greater postoperative comfort, which also reduces hospitalization time and convalescence in general [5-28-29].

On the other hand, Sánchez et al. (2021) state that, within the surgical approaches, laparoscopic fundoplication is preferred over open surgery since perioperative complications are reduced, patients have a shorter hospital stay, and there is less morbidity [30-31]. Likewise, Rosen et al. (2018) observed an improvement in the quality of life of pediatric patients by 86% after surgery [32].

New randomized studies should be considered in the future in this line of research.

## Conclusions

Recognizing that the diversity found in patients with gastroesophageal reflux and swallowing disorders linked to infantile cerebral palsy pathology has been complex, it is interesting to observe how minimally invasive surgery is displacing open surgery, concluding in the study that by comparing both surgical techniques, the research findings confer an advantage to the minimally invasive percutaneous gastrostomy technique with Nissen fundoplication, where there were fewer complications and in less than 48 hours the patients began feeding through the gastrostomy tube.

## Abbreviations

NF: Nissen fundoplication  
ICP: infantile cerebral palsy

## Supplementary information

Supplementary materials are not declared.

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## Author contributions

Rommel Gonzalo Oviedo-Vargas: Conceptualization, Data Retention, Fundraising, Research, Resources, Software, Writing - original draft.  
Juliors Francisco Gonzales-Navarro: Conceptualization, Data Retention, Supervision, Fundraising, Research, Resources, Writing: proofreading and editing.  
Cristhian Renán Cedeño-Moreira: Data curation, research, fundraising, supervision, methodology.  
Jorge Alejandro Oliveros-Rivero: conceptualization, data conservation, supervision, visualization, methodology.  
Daniel Benigno Acosta-Farina: Conceptualization, Data Conservation, Fund Acquisition, Research.  
All authors read and approved the final version of the manuscript.

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## Availability of data and materials

The data sets generated and analyzed during the current study are not publicly available due to participant confidentiality but are available through the corresponding author upon reasonable academic request.

## Statements

### Ethics committee approval and consent to participate

The Ethics Committee approved the research protocol of the Teaching Committee of the Dr. Roberto Gilbert Elizalde Children's Hospital.

### Publication consent

It does not apply to studies that do not publish MRI/CT/Rx images or physical examination photographs.

### Conflicts of interest

The authors declare no conflicts of interest.

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