ASTR

ORIGINAL ARTICLE
pISSN 2288-6575 • eISSN 2288-6796
https://doi.org/10.4174/astr.2025.108.3.177
Annals of Surgical Treatment and Research

# A single center experience on clinical outcome of fundoplication in pediatric patients: a retrospective cohort study

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**Purpose:** The study aimed to evaluate the characteristics and operative-related factors in children who underwent fundoplication, analyze surgical outcomes categorized by disease entity and surgical indication, and identify prognostic factors for reoperation risk.
**Methods:** A total of 109 pediatric patients who underwent fundoplication between 2008 and 2022 were retrospectively analyzed. Patients were grouped by disease entity and surgical indication. Underlying diseases, comorbidities, sex, gestational age, birth weight, preoperative symptoms, and operation-related factors were examined. Outcomes were classified as short-term and long-term adverse events. We investigated differences in clinical outcomes according to disease entity and surgical indication. Then we statistically identified preoperative predictors for the risk of reoperation.
**Results:** The most common disease entity was neurological impairment (n = 92). Pulmonary comorbidity (42.2%) and aspiration/regurgitation (87.2%) were the most common. Most surgeries were performed laparoscopically (86.2%). There were 12 short-term and 25 long-term adverse events, with long-term events occurred more frequently in the neurological impairment (NIP) group compared to the non-NIP group (P = 0.04). None of the factors showed a significant relationship with the risk of reoperation.
**Conclusion:** Neurologically impaired children were more likely to experience long-term adverse events post-fundoplication. However, no significant predictors for reoperation risk were identified.
**[Ann Surg Treat Res 2025;108(3):177-185]**

**Key Words:** Child, Fundoplication, Gastroesophageal reflux, Pediatrics

## INTRODUCTION

Nissen fundoplication is the most common anti-reflux surgery performed in pediatric patients. Almost all pediatric patients undergoing fundoplication have medically intractable gastroesophageal reflux disease (GERD) with other comorbidities [1,2]. Meanwhile, a few patients without GERD undergo fundoplication for prophylactic purposes, and some studies suggest that fundoplication is effective even in cases of mild GERD, where the symptoms are relatively mild [3]. For those undergoing fundoplication due to medically refractory GERD, the procedure aims to control GERD symptoms, prevent related complications, and ensure adequate nutrition for growth [4]. In fact, 5%–7% of children suffer from GERD, and notably,

**Received** November 11, 2024, **Revised** December 3, 2024,
**Accepted** December 17, 2024

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26%–91% of children with neurological impairment (NIP) are known to have GERD [5-7]. Since GERD-related aspiration pneumonia is the most significant cause of death in children with NIP, fundoplication, as an anti-reflux surgery to address it, should be treated with importance.

Although Nissen fundoplication is commonly performed for both GERD and prophylactic purposes, little is known about the long-term outcomes and effectiveness. In addition, according to previous studies, the subsets of patients with a higher operation failure rate include those with associated respiratory conditions, NIPs, esophageal atresia, and infants under the age of 1 year [8-11]. Some literature suggests these medical conditions may lead to a greater likelihood of surgical failure; there is also research showing that if the preoperative response to proton pump inhibitors is good, the surgical outcome is significantly better [12]; however, few studies provide definitive answers on whether these preexisting conditions or initial surgical approaches affect the clinical outcome.

Therefore, in our study, we aimed to retrospectively analyze the clinical outcomes of pediatric patients who underwent Nissen fundoplication at Seoul National University Children's Hospital. First, we evaluated the general characteristics of children who underwent fundoplication and investigated operation-related factors. We examined the clinical outcomes of fundoplication and analyzed surgical results among patients categorized by disease entity and indication for surgery. As a secondary aim, we also sought predictive factors that could be used to forecast post-fundoplication outcomes.

## METHODS

We conducted a retrospective study of pediatric patients who underwent Nissen fundoplication. The study included 113 patients who underwent Nissen fundoplication between 2008 and 2022. All data collection and analysis were performed after obtaining approval from the Institutional Review Board of Seoul National University Hospital (No. 1707-119-872). Informed consent was not required because of the retrospective nature of

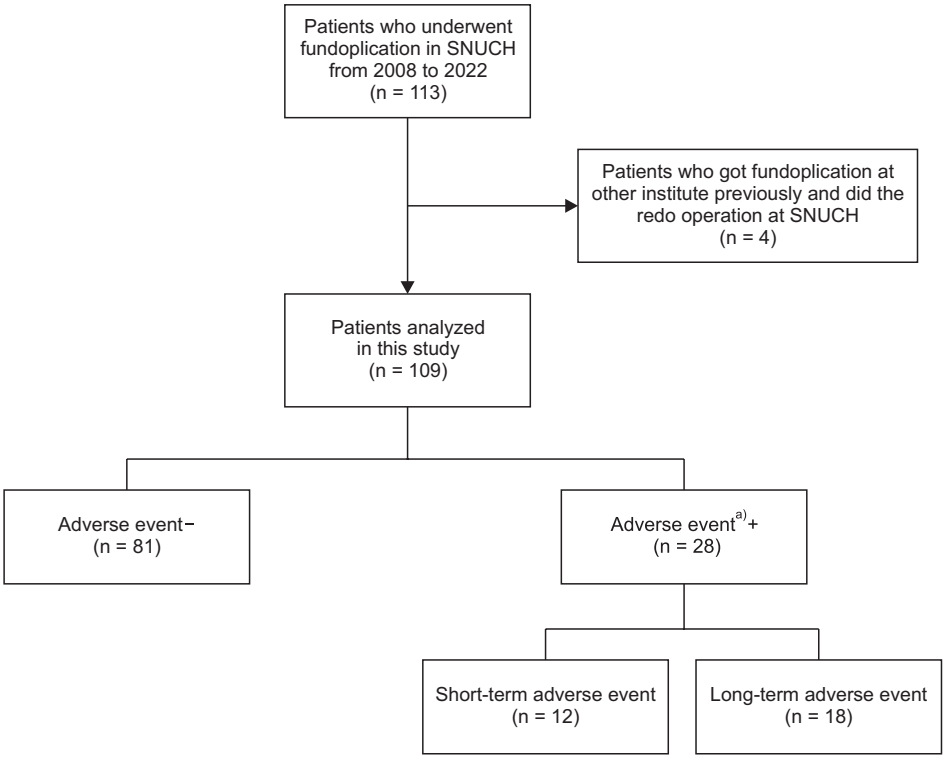


**Fig. 1.** Flow diagram. The total number of patients analyzed, along with the inclusion and exclusion criteria, were described. Additionally, a brief description of the clinical outcomes and the definition of adverse events were provided. SNUCH, Seoul National University Children's Hospital.

this study.

Four patients who had undergone fundoplication at another institute previously and then underwent a redo fundoplication at our institute were excluded (Fig. 1). A total of 109 patients were analyzed in this study. The mean follow-up period was 3.3 ± 3.0 years (mean ± standard deviation) with a maximum of 11-year follow-up.

The data collected for each patient included underlying disease (classified as neurological [NIP], muscular, or others), demographics (sex, gestational age, or birth weight), comorbidity, preoperative symptoms, and preoperative evaluations (upper gastrointestinal series [UGIS] and/or 24-hour pH monitoring). Details also encompassed operation-related statistics such as age and body weight at the time of operation, duration of operation, anesthesia time, and surgical methods (open and laparoscopy), along with concurrent procedures (gastrostomy with timing and pyloroplasty).

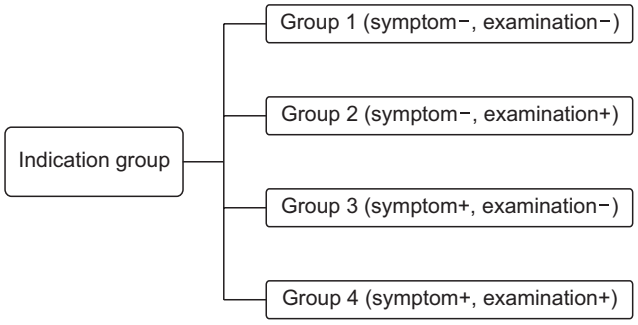


**Fig. 2.** Definition of indication group. The definition of the indication group, classified by preoperative symptoms and results of preoperative examinations, was provided. Symptom: aspiration, regurgitation, or vomiting (representative symptoms of gastroesophageal reflux [GER]). Examination: upper gastrointestinal series or pH monitoring found GER.

Patients were categorized into disease groups: NIP, muscular disease, and others. Based on the presence or absence of preoperative symptoms and results of preoperative tests, patients were divided into 4 indication groups, as depicted in Fig. 2. Group 1 included patients without preoperative gastroesophageal reflux (GER) symptoms, with no confirmation of GER on preoperative examination, undergoing fundoplication for prophylactic purposes, especially for those bedridden and at risk of future GERD. Group 2 consisted of patients without preoperative GER symptoms but diagnosed with GER during examinations; these individuals were often scheduled for other surgeries like tracheostomy or gastrostomy, where GER was incidentally detected. Group 3 encompassed patients presenting with preoperative GER symptoms yet without confirmation by tests. Group 4 included patients with confirmed GER by examinations, accompanied by symptoms.

We assessed whether concurrent procedures like gastrostomy (noting the timing as pre-, post-, or intraoperative) and pyloroplasty were performed simultaneously with

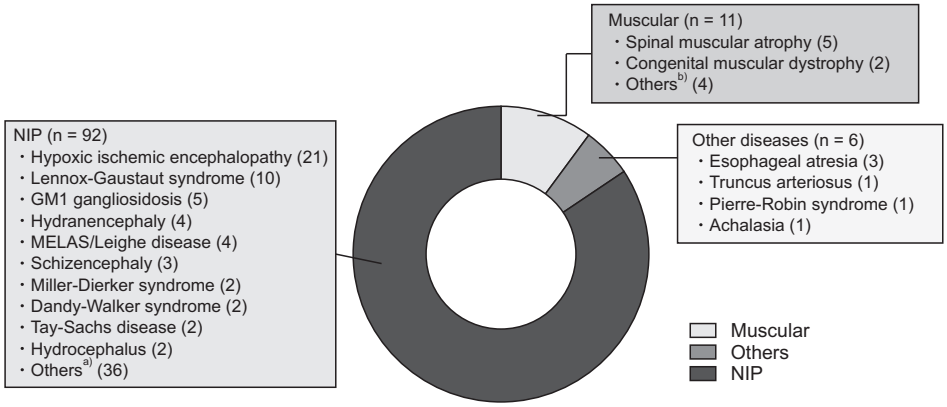


**Fig. 3.** Disease entity. The main disease group of patients is depicted in a graph, classified into neurological, muscular, and other diseases. Additionally, the lists of each disease entity and the number of patients were provided. GM1, ganglioside monosialic acid 1; MELAS, mitochondrial encephalomyopathy, lactic acidosis, and stroke-like episodes. [a]Others (neurological impairment) include Dravet syndrome, Charcot-Marie-Tooth disease, Beare-Stevenson syndrome, Phelan-McDermid syndrome, Krabbe disease, fetal alcohol syndrome, Pelizaeus-Merzbacher disease, Schaaf-Yang syndrome, GNA01 encephalopathy, glycine encephalopathy, Coffin-Siris syndrome, Allan-Herdon-Dudley syndrome, febrile infection-related epilepsy syndrome, Wolf-Hirshhorn syndrome, ATRX syndrome, methyl-CpG-binding protein 2 duplication syndrome, West syndrome, metachromatic leukodystrophy, Menkes disease, radiotherapy-induced encephalopathy, X-linked adrenoleukodystrophy, acute disseminated encephalomyelitis, q23.1 deletion syndrome, CASK-related developmental and epileptic encephalopathy and brain atrophy, ventriculomegaly, holoprosencephaly, EI12AK2 het c.325G>Tp.Alal09Ser *de novo* confirmed microcephaly simplified gyral pattern, neonatal periventricular leukomalacia, DYNC1H1 missense p.Lys4406Gln *de novo* (not in Human Gene Mutation Database), 3q26.1q26.2 deletion, Chr 22q22.33q11.1 8.60b deletion, TWE 513 RNA polymerase III subunit A, p.Leu617Pro/c.1771-6C>G comhet confirmed (tramn), central hypotonia, anaplastic ependymoma, Down syndrome with status epilepticus, neuro-regression of unknown etiology. [b]Others (muscular disease) include Fukuyama congenital muscular dystrophy, Duchenne muscular dystrophy, nemalin rod myopathy, SPG11-related neuromuscular disease.

fundoplication. Clinical outcomes of fundoplication were examined and categorized as short-term outcomes and long-term outcomes, with adverse events during each period investigated.

In terms of postoperative outcomes, we investigated the occurrence of adverse events and the cases that required reoperation. Adverse events were defined as follows: short-term adverse events were those that occurred during the hospitalization period, usually within 2 weeks after surgery. Long-term adverse events were defined as events such as loosening, hiatal hernia, aspiration pneumonia, and ileus that occurred after discharge. Long-term adverse events were those that occurred after discharge and required rehospitalization.

We explored potential differences in clinical outcomes based on disease entity and indication groups (groups 1 to 4). We also examined whether demographic or operation-related variables might influence the clinical outcome of fundoplication. We conducted the Fisher exact test and calculated the odds ratio with P-value for variables. To assess differences among more than 3 variables, we conducted an analysis of variance test. Statistical analysis was completed using IBM SPSS Statistics for Windows, ver. 7.1 (IBM Corp.). In all reported P-values, <0.05 were considered significant.

## RESULTS

Disease entity and demographic statistics for 109 patients were summarized in Fig. 3 and Table 1. The most common comorbidity was pulmonary disease, often necessitating tracheostomy formation for conditions such as bronchopulmonary dysplasia, persistent asthma, recurrent pneumonia, and oxygen supplementation needs. Gastrointestinal and cardiologic comorbidities were more prevalent in the non-NIP group than in the NIP group, with significant statistical differences (12.0% *vs.* 35.3%, P = 0.025; 7.6% *vs.* 29.4%, P = 0.020). The gastrointestinal comorbidities included conditions like esophageal atresia and intestinal malrotation.

Preoperative symptoms such as aspiration/regurgitation were the most common, followed by respiratory distress and vomiting. Aspiration/regurgitation was more frequent in the NIP group, while vomiting prevailed in the non-NIP group (P = 0.045 and P = 0.016, respectively).

For indication groups, only 4 cases in group 1 underwent

**Table 1.** Baseline descriptive characteristics

| Characteristic | Total | NIP group | Non-NIP group | P-value |
|---|---|---|---|---|
| No. of patients | 109 | 92 | 17 | |
| Gestational age (wk) | 37.01 ± 4.41 | 37.19 ± 4.31 | 33.80 ± 5.26 | 0.510 |
| Male sex | 71 (65.1) | 62 (67.4) | 9 (52.9) | 0.191 |
| Birth weight (kg) | 2.75 ± 0.84 | 2.80 ± 0.85 | 2.21 ± 0.69 | 0.144 |
| Comorbidity | | | | |
| Pulmonary | 46 (42.2) | 8 (40.2) | 9 (52.9) | 0.238 |
| Gastrointestinal | 17 (15.6) | 11 (12.0) | 6 (35.3) | 0.025* |
| Cardiologic | 12 (11.0) | 7 (7.6) | 5 (29.4) | 0.020* |
| Musculoskeletal | 12 (11.0) | 12 (13) | 0 (0) | - |
| Endocrine | 10 (9.2) | 8 (8.7) | 2 (11.8) | 0.484 |
| Other anomalies | 24 (22.0) | 20 (21.7) | 4 (23.5) | 0.545 |
| Preoperative symptom | | | | |
| Aspiration/regurgitation | 95 (87.2) | 75 (81.5) | 10 (58.8) | 0.045* |
| Respiratory distress | 46 (42.2) | 42 (45.7) | 4 (23.5) | 0.074 |
| Vomiting | 36 (33.0) | 26 (28.3) | 10 (58.8) | 0.016* |
| POI/feeding difficulty | 22 (20.2) | 19 (20.7) | 3 (17.6) | 0.537 |
| Weight loss | 3 (2.8) | 2 (2.2) | 1 (5.9) | 0.402 |
| Preoperative medication | | | | |
| No | 50 (45.9) | 45 (48.9) | 5 (29.4) | |
| Yes | 59 (54.1) | 47 (51.1) | 12 (70.6) | 0.111 |
| Duration of medication (day), range | 23–3,562 | 23–3,562 | 52–1,684 | 0.319 |
| Indication group | | | | 0.742 |
| Group 1 | 4 (3.7) | 3 (3.3) | 1 (5.9) | |
| Group 2 | 7 (6.4) | 5 (5.4) | 2 (11.8) | |
| Group 3 | 21 (19.3) | 17 (18.5) | 4 (23.5) | |
| Group 4 | 63 (57.8) | 13 (14.1) | 9 (52.9) | |
| No exam done preoperatively | 14 (12.8) | 13 (14.1) | 1 (5.9) | |

Values are presented as number only, mean ± standard deviation, or number (%) unless otherwise specified.
NIP, neurological impairment; POI, poor oral intake.
*P < 0.05, statistically significant.

fundoplication for purely prophylactic purposes. Seven cases in group 2 were incidentally diagnosed with GER during examinations without definitive symptoms. Twenty-one cases in group 3 underwent fundoplication due to symptoms inconsistent with examination results. Group 4 was the most common, including 63 patients. However, 14 cases had neither UGIS nor 24-hour pH monitoring conducted preoperatively. There was no statistically significant difference in the composition of indication groups between the NIP and non-NIP groups (group 1, 3.3% *vs.* 5.9%; group 2, 5.4% *vs.* 11.8%; group 3, 18.5% *vs.* 23.5%; group 4, 14.1% *vs.* 52.9%; P = 0.742).

## Operation-related statistics

Details of operation-related statistics, including comparison between the NIP and non-NIP groups, are summarized in Table 2. For those who underwent fundoplication, there was no statistically significant difference in operation-related variables between the NIP and non-NIP groups. However, among the operation methods, 15 cases (13.8%) utilized the open method, including 2 conversions to open due to adhesion. 9.8% of procedures in the NIP group were open, compared to 35.3% in the non-NIP group, showing a statistically significant difference (P = 0.013).

In 102 out of 109 cases (93.6%), gastrostomy was performed either simultaneously with fundoplication, before it, or afterward. In the NIP group, 76 patients underwent simultaneous gastrostomy with fundoplication, while in the non-NIP group, 14 patients had gastrostomy with fundoplication. This difference was statistically significant (P = 0.001).

## Outcomes post-fundoplication

As detailed in Table 3, a total of 12 short-term adverse events occurred, with 10 happening in the NIP group. However, the frequency of short-term adverse events did not show a statistically significant difference depending on the disease entity.

Long-term adverse events occurred in a total of 25 for 18 patients, including 9 cases of loosening of the fundoplication wrap, 7 of hiatal hernia, 6 of long-term aspiration pneumonia, and 3 of ileus. Among these 18 patients, 17 were in the NIP group while only 1 long-term adverse event occurred in the non-NIP group. Long-term adverse events tended to occur more frequently in the NIP group, showing statistical significance (P = 0.043).

In this study, among long-term adverse events, the loosening of the fundoplication wrap and hiatal hernia were considered significant due to their strong association with the risk of reoperation. There were 9 cases of loosening and 7 cases of hiatal hernia, with 4 cases experiencing both simultaneously, resulting in a total of 12 significant adverse events.

Of the patients who underwent Nissen fundoplication at our institute, 4 required reoperation. Table 4 summarizes these reoperation cases. Additionally, there were 9 cases of expiry, but no operation-related deaths occurred during the study period. The cause of death was the exacerbation of the underlying disease.

In addition, we analyzed whether there was a difference in adverse events among the defined indication groups, finding no statistically significant difference in short- and long-term adverse events between these 4 groups as described in Table 5.

Table 6 displays the results of Fisher exact test comparing the risk of reoperation, choosing significant adverse events as outcome variables. According to the statistical analysis, sex, preterm birth, and underweight birth (less than 2.5 kg) demonstrated no statistically significant relationship with the risk of significant adverse events, nor did the presence or absence

**Table 2.** Comparison of operation-related factors between the NIP and non-NIP groups

| Factor | Total (n = 109) | NIP group (n = 92) | Non-NIP group (n = 17) | P-value |
|---|---|---|---|---|
| Age at operation (mo) | 72.0 ± 68.9 | 82.2 ± 69.6 | 81.2 ± 95.1 | 0.060 |
| Body weight at operation (kg) | 15.3 ± 9.2 | 17.0 ± 8.7 | 14.53 ± 13.2 | 0.068 |
| BMI at operation (kg/m$^2$) | 13.79 ± 8.62 | 15.24 ± 3.45 | 13.25 ± 2.48 | 0.477 |
| Operation time (min) | 120 ± 57.7 | 121 ± 60.2 | 114 ± 18.6 | 0.256 |
| Anesthetic time (min) | 163 ± 61.3 | 160 ± 64.0 | 178 ± 47.4 | 0.225 |
| Operation method | | | | 0.013* |
| Open[a] | 15 (13.8) | 9 (9.8) | 6 (35.3) | |
| Laparoscopy | 94 (86.2) | 83 (90.2) | 11 (64.7) | |
| Gastrostomy | 102 (93.6) | 88 (95.7) | 14 (82.4) | 0.001* |
| With fundoplication | 87 (79.8) | 76 (82.6) | 11 (64.7) | |
| Before fundoplication | 13 (11.9) | 12 (13.0) | 1 (5.9) | |
| After fundoplication | 2 (1.8) | 0 (0) | 2 (11.8) | |
| Pyloroplasty | 7 (6.4) | 4 (4.3) | 3 (17.6) | 0.075 |

NIP, neurological impairment; BMI, body mass index.
[a]There were 2 open conversion cases due to adhesion.
*P < 0.05, statistically significant.

**Table 3.** Clinical outcome of Nissen fundoplication according to the disease entity

| Variable | Total (n = 109) | NIP group (n = 92) | Non-NIP group (n = 17) | P-value |
|---|---|---|---|---|
| Short-term outcome | | | | |
| Adverse event | 12 (11.0) | 10 (10.9) | 2 (11.8) | 0.341 |
| Reintubation | 5 | 5 | 0 | - |
| Pleural effusion[a] | 1 | 1 | 0 | - |
| Aspiration pneumonia | 1 | 1 | 0 | - |
| GI bleeding | 1 | 0 | 1 | - |
| Stroke | 1 | 1 | 0 | - |
| Rhabdomyolysis | 1 | 1 | 0 | - |
| Dumping syndrome | 1 | 0 | 1 | - |
| GED[b] | 1 | 1 | 0 | - |
| Long-term outcome | | | | |
| Adverse event[c] | 18 (16.5) | 17 (18.5) | 1 (5.9) | 0.043* |
| Loosening of fundoplication[d] | 9 | 8 | 1 | 0.245 |
| Hiatal hernia[d] | 7 | 7 | 0 | - |
| Aspiration pneumonia | 6 | 6 | 0 | - |
| Ileus | 3 | 3 | 0 | - |
| Redo fundoplication | 4 | 3 | 1 | 0.498 |

Values are presented as number (%) or number only.
NIP, neurological impairment; GI, gastrointestinal; GED, gastric emptying delay.
[a]Pleural effusion requiring thoracentesis. [b]GED requiring percutaneous endoscopic jejunostomy insertion. [c]n = 25 for 18 patients. [d]Loosening of fundoplication and hiatal hernia are termed 'significant' adverse events.
*P < 0.05, statistically significant.

**Table 4.** Summary of reoperation cases

| Variable | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Age at the first operation (mo) | 3 | 185 | 7 | 43 |
| Interval between the first operation and reoperation (mo) | 25 | 23 | 26 | 17 |
| Symptom requiring reoperation | Aspiration | Aspiration | Aspiration | Aspiration |
| UGIS finding | Hiatal hernia and wrap loosening | Loosening of wrap | Hiatal hernia and wrap loosening | Hiatal hernia and wrap loosening |
| Intraoperative findings during reoperation | Hiatal hernia repair and wrap reinforcement done | Open conversion due to severe adhesion and esophagus tear<br>Wrap reinforcement done | Hiatal hernia repair and wrap reinforcement done | Hiatal hernia repair and wrap reinforcement done |
| Follow-up after reoperation | Relief of symptom<br>Mild loosening at UGIS | Intermittent vomiting<br>Mild loosening at UGIS | Relief of symptom | Relief of symptom |

UGIS, upper gastrointestinal series.

of preoperative symptoms and the surgical method used.

## DISCUSSION

In this study, we explored the incidence of several complications and factors that could influence the clinical outcome of Nissen fundoplication. Previous studies analyzing the clinical outcome of fundoplication were limited by the large heterogeneity of the patient groups, making them difficult to categorize. Martin et al. [13], in their critical review, noted that most studies involving pediatric patients undergoing fundoplication are of low quality and suffer from significant heterogeneity, which limits the ability to pool outcomes. Therefore, in our study, the indication group was divided into 4 based on the major preoperative symptoms (vomiting, aspiration, or regurgitation) and the presence or absence of GER in the examination. This approach is noteworthy as it constitutes the first study to demonstrate no significant difference in the occurrence of postoperative adverse events between these indication groups.

**Table 5.** Clinical outcome of Nissen fundoplication according to indication group

| Variable | Group 1 (n = 4) | Group 2 (n = 7) | Group 3 (n = 21) | Group 4 (n = 63) | P-value |
|---|---|---|---|---|---|
| Short-term outcome | | | | | |
| Adverse event | 0 (0) | 1 (14.3) | 4 (19.0) | 5 (7.9) | 0.580 |
| Reintubation | 0 | 0 | 1 | 4 | |
| Pleural effusion[a] | 0 | 1 | 0 | 0 | |
| Aspiration pneumonia | 0 | 0 | 0 | 0 | |
| GI bleeding | 0 | 0 | 1 | 0 | |
| Stroke | 0 | 0 | 1 | 0 | |
| Rhabdomyolysis | 0 | 0 | 0 | 0 | |
| Dumping syndrome | 0 | 0 | 0 | 1 | |
| GED[b] | 0 | 0 | 1 | 0 | |
| Long-term outcome | | | | | |
| Adverse event[c] | 0 (0) | 1 (14.3) | 3 (14.3) | 14 (22.7) | 0.696 |
| Loosening of fundoplication[d] | 0 | 1 | 1 | 7 | |
| Hiatal hernia[d] | 0 | 1 | 0 | 6 | |
| Aspiration pneumonia | 0 | 0 | 1 | 5 | |
| Ileus | 0 | 0 | 1 | 2 | |
| Redo fundoplication | 0 | 0 | 0 | 4 | |

Values are presented as number (%) or number only.
Refer to Fig. 2 for group definitions.
GI, gastrointestinal; GED, gastric emptying delay.
[a]Pleural effusion requiring thoracentesis. [b]GED requiring percutaneous endoscopic jejunostomy insertion. [c]n = 25 for 18 patients. [d]Loosening of fundoplication and hiatal hernia are termed 'significant' adverse events.

**Table 6.** Fisher exact test results comparing the risk for reoperation

| Variable | Proportion of significant adverse events[a] (%) | Odds ratio | P-value |
|---|---|---|---|
| Sex | | | |
| Female | 33.3 | 1 (Reference) | |
| Male | 66.7 | 1.079 | 0.590 |
| Prematurity | | | |
| Full term | 72.7 | 1 (Reference) | |
| Premature | 27.3 | 0.990 | 0.648 |
| Birth weight | | | |
| Normal | 63.6 | 1 (Reference) | |
| Low birth weight | 36.4 | 1.500 | 0.380 |
| Preoperative symptom[b] | | | |
| Vomiting | 50 | 2.233 | 0.158 |
| Cough | 16.7 | 0.371 | 0.172 |
| Reflux/aspiration | 75 | 0.829 | 0.519 |
| Respiratory distress | 33.3 | 0.655 | 0.368 |
| Fever | 16.7 | 0.406 | 0.210 |
| POI/feeding difficulty | 16.7 | 0.770 | 0.548 |
| Weight loss | 0 | - | - |
| Hematemesis | 8.3 | 8.727 | 0.209 |
| Operation method | | | |
| Laparoscopy | 91.7 | 1 (Reference) | |
| Open | 8.3 | 0.539 | 0.483 |

POI, poor oral intake.
[a]Significant adverse events mean either of loosening of fundoplication wrap or hiatal hernia (which are highly related to reoperation risk). [b]Reference: no specific symptoms.

In addition to previous studies primarily focusing on fundoplication in patients with medically intractable GERD, we also aimed to analyze a smaller subset undergoing this procedure for prophylactic reasons. As studies indicate, several demographic features vary among different disease entities. First, gastrointestinal and cardiologic comorbidity exhibited

a higher incidence in the non-NIP group compared to the NIP group. This is because patients in the non-NIP group who underwent fundoplication predominantly had severe GERD due to congenital anomalies and combined syndromes such as esophageal atresia and CHARGE (coloboma, heart defects, atresia choanae, retarded growth and development, genital abnormalities, ear abnormalities and/or deafness) syndrome. Moreover, while aspiration was more common in the NIP group, vomiting was predominant in the non-NIP group, as it includes patients with esophageal atresia and achalasia, whose representative symptom is vomiting. Furthermore, the non-NIP group tends to prefer laparotomy over laparoscopy for surgical methods. This preference is likely due to the characteristics of our center, the period of surgery, and the expanded indications for fundoplication. In the non-NIP group, all 5 of the 6 open cases occurred before 2015. Before 2015, most children undergoing fundoplication had severe GERD rather than NIP, with a shift in the indications for fundoplication to include patients in the NIP group occurring thereafter. In other words, the observed statistical difference appears to stem from the predominance of open surgery before 2015, during which time fundoplication was less common in patients in the NIP group.

Several previous retrospective studies have suggested that patients with NIP experience higher complications or operation failure rates than those in the normal neurology group (NN group) [14-16]. Martin et al. [13] reported that the reoperation rate in patients with NIP was 15.4 ± 4.2% compared to 7.0 ± 3.3% in patients with NN, with this difference being statistically significant ($P = 0.003$). Conversely, a prospective cohort study by Stellato et al. [17] revealed no correlation between the presence of NIP and the severity of postoperative reflux recurrence. In our study, 17 of the 18 cases of long-term adverse events occurred in the NIP group, aligning more with Martin et al's findings [14] than with Stellato et al.'s [17], and there continues to be debate over the influence of NIP on surgical outcomes in pediatric patients. Furthermore, a study by Pascoe et al. [18] found no significant correlation between the presence of comorbidity and outcomes. Additionally, infants under the age of 1 year did not show a higher reoperation rate, corroborating our research results.

For short-term adverse events, it is noteworthy that all 5 cases of respiratory complications requiring reintubation occurred only in the NIP group. Among these 5 reintubation cases, one was an 'extubation failure' necessitating immediate reintubation, while the other 4 were due to desaturation events or stridor occurring after a certain period post-extubation. There were instances where difficulty with extubation resulted in tracheostomy formation.

In our study, long-term adverse events occurred more frequently in the NIP group. We suggest 2 reasons for this observation: firstly, aspiration is primarily symptomatic in the NIP group preoperation; secondly, the rigidity in the NIP group tends to facilitate the development of hiatal hernias more readily than in the non-NIP group. However, whether the NIP group is more prone to loosening of the fundoplication wrap compared to the NN group remains controversial, necessitating additional research.

However, our study has some limitations. Interpretations of surgical success vary among studies, and there is a lack of well-defined outcomes or endpoints. Additionally, there is insufficient prior investigation into whether optimal medical management was employed before surgery. Moreover, in terms of adverse event, distinguishing whether an event is genuinely related to surgery or simply occurred naturally due to an underlying disease or other factors unrelated to the surgery is extremely challenging. For example, in the case of long-term adverse events like aspiration pneumonia, it is difficult to determine whether it resulted from reflux recurrence after fundoplication or was merely a simple aspiration event (possibly due to underlying conditions such as laryngomalacia or other predispositions to aspiration). Due to the retrospective nature of this study, it is particularly challenging to differentiate—based solely on chart reviews—whether the etiology of aspiration pneumonia is related to the surgery or whether it is an event that could occur in patients with NIP regardless of the surgical intervention.

Additionally, despite a detailed exploration of reoperation cases, interim to reoperation, and subsequent follow-up, the indication for reoperation was not clearly articulated. Indeed, the reoperation rate varies significantly from study to study, underscoring the need for more research as there is no consensus yet on the indications for reoperation.

Speaking of reoperation, as described in Table 6, there were no preoperative variables that could predict the risk of reoperation. However, the fact that there were only 4 cases of reoperation out of 109 cases makes it difficult to define the odds ratio, which is also a limitation of this study.

Finally, this study is retrospective and monocentric, with its inevitable limitation being the small sample size.

In conclusion, this study analyzed clinical outcomes of fundoplication based on disease entities and groups classified by surgical indications. Long-term adverse events were more prevalent in the NIP group than in the non-NIP group. Clinical outcomes showed no differences among indication groups. We also determined that the correlation between various factors and the risk of reoperation did not achieve statistical significance.

Consensus on surgical indications, criteria for reoperation, and definitions of surgical failure in fundoplication patients need to be established more broadly, and a wider range of prospective studies is recommended.

## ACKNOWLEDGEMENTS

### Fund/Grant Support

None.

### Conflict of Interest

Hee-Beom Yang, serving as an member of the Editorial Board of *Annals of Surgical Treatment and Research*, did not participate in the review process of this article. No other potential conflicts of interest pertinent to this article were reported.

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Methodology: YO, DK
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