

Review Article

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Reconstruction of the Phrenoesophageal Ligament: An Alternative to Avoid Post-Fundoplication Paraesophageal Hernia in Children

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ABSTRACT

Purpose: Migration of Nissen fundoplication to the thorax is a frequent complication of antireflux surgery. Occurring in up to 12% of children. Achieving adequate intra-abdominal esophageal length requires dissection of the phrenoesophageal membrane. The primary objective of this study was to assess the effectiveness of phrenoesophageal membrane reconstruction in preventing thoracic migration of the fundoplication in children undergoing laparoscopic surgery.

Methods: Retrospective cohort study of 690 children undergoing laparoscopic fundoplication, Group A without membrane reconstruction, and Group B with membrane reconstruction. The outcome was intrathoracic migration of the postoperative fundoplication. Odds ratio (OR) and 95% confidence intervals (CI) were calculated with $p \leq 0.05$.

Results: A total of 631 patients met inclusion criteria, 52.1% in Group A and 47.9% in Group B. Intrathoracic migration occurred in 7.0% in Group A and 1.3% in Group B ($p < 0.001$). Phrenoesophageal reconstruction in Group B resulted in an 82.1% reduction in the likelihood of migration (OR 0.179; 95% CI: 0.06-0.52).

Conclusion: This study highlights the need to perform a reconstruction of the phrenoesophageal membrane when performing a fundoplication in children, which significantly reduces the intrathoracic migration of fundoplication.

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Introduction

Laparoscopic Nissen fundoplication is the procedure of choice for treating children with gastroesophageal reflux disease. Some essential aspects of the procedure include identification of the esophagogastric junction and provision of an adequate portion of intra-abdominal esophagus, which requires incision of the phrenoesophageal membrane and the gastrohepatic ligament. The most frequent complication of this procedure is intrathoracic migration of the fundoplication, which has led to changes in surgical technique in an attempt to prevent it. It has been proposed to preserve the phrenoesophageal membrane through minimal esophageal dissection, a technique that, in the short term, was shown to reduce complications by up to 5%. However, when followed up long-term, complications occurred in 12% of patients. In patients with intrathoracic migration of the fundoplication, it has been documented that this happens in the anterior part of the hiatus, where the phrenoesophageal membrane is usually located [1-12].

Although Allison considered the repair of this membrane to be crucial during antireflux procedures since 1951, this reconstruction is not part of the fundoplication technique in children [2,13-17].

This study aims to evaluate the efficacy of phrenoesophageal membrane reconstruction during laparoscopic Nissen-type antireflux procedures in children, with the goal of preventing intrathoracic migration of the fundoplication.

Patients and Methods

All patients under 18 years of age who primarily required laparoscopic Nissen Fundoplication treated by a single surgical group at our hospital (a high-volume center specialized in minimally invasive surgery in children) from January 1, 2013 to June 15, 2023 were included.

This study was approved by the hospital's teaching and research committee. Informed consent was obtained from the responsible guardian of each patient.

Patients were Grouped According to Surgical Technique

Group A: Patients who underwent 360-degree Nissen fundoplication by laparoscopy, without reconstruction of the phreno-esophageal membrane.

Group B: Patients who underwent 360-degree Nissen fundoplication by laparoscopy with reconstruction of the phreno-esophageal membrane.

Group A was treated from January 2013 to December 2018, and Group B from January 2019 to June 2023. The evolution and characteristics of the two groups were analyzed and compared.

Patients over 18 years old, those with a history of antireflux surgery, congenital malformations, or short esophagus were excluded. Patients with missing or incomplete data were excluded from the final analysis to avoid bias.

The primary outcome (operational definition) was intrathoracic migration of the fundoplication, confirmed by endoscopy or contrast radiological study. A scheduled evaluation was performed 6 months after surgery in all patients, and subsequently, if symptoms suggestive of reflux reappeared.

No sample size calculation or statistical power analysis was performed a priori, as this was a retrospective cohort study. The absence of a power calculation was considered a limitation of the study.

Patients in both groups were studied according to our protocol, which included age, sex, weight, main symptoms (grouped into digestive, respiratory, and neurological categories), contrast radiological study, and preoperative endoscopy.

Patients were followed up clinically at one month, and then every 6 months for the duration of the study, asking them about heartburn, persistent cough, sialorrhea, dysphagia, irritability, epigastric pain, and vomiting. An endoscopy or contrast study was performed in all patients six months after the surgery. These same studies were repeated if the patient again presented signs of gastroesophageal reflux during the follow-up period to rule out intrathoracic migration of the fundoplication.

Patients who presented with fundoplication herniation, as demonstrated by endoscopy or radiological study, were analyzed for accompanying symptoms, including radiological and endoscopic findings, time of onset, and resolution.

Surgical Technique

Patients in both groups were treated with general anesthesia and orotracheal intubation, four-port approach of 3 and 5 mm, with a 5 mm and 30-degree optic, 8 mm Hg insufflation, the gastro hepatic ligament was dissected with a harmonic scalpel (Harmonic Ace, Ethicon, USA). A percutaneous suture was placed for liver separation with 2-0 silk (Ethicon USA). Short vessels were dissected using a harmonic scalpel. The right pillar was identified, and the phreno-esophageal ligament was dissected and released until two to three centimeters of the abdominal esophagus were exposed. A pillar plasty was performed with two 2-0 polyester sutures (Ethibond, Ethicon USA), and a loose and aligned fundoplication was constructed with three polyester sutures. (Figure. 1 Nissen without membrane repair) Patients in group B also underwent reconstruction of the phreno-esophageal membrane, addressing only the right and left layers of the membrane, without including the diaphragm, and fixing it to the

esophagus with 3-0 polyester suture (Ethibond, Ethicon USA). (Figure 2: Reconstruction and Nissen with membrane repair)

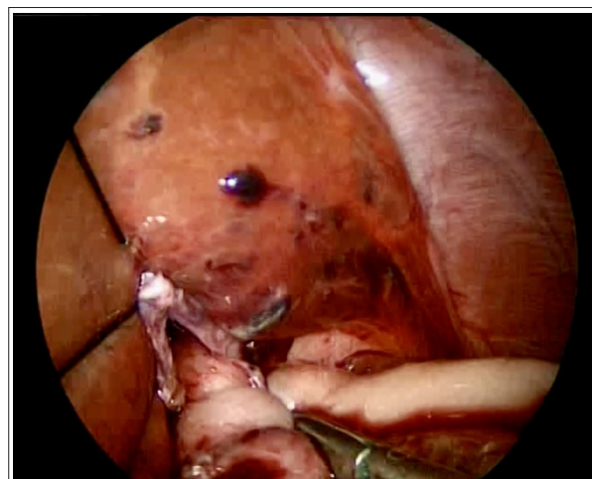


Figure 1: Image of Fundoplication without Membrane Reconstruction (Group A), Communication to the Thorax can be Seen.

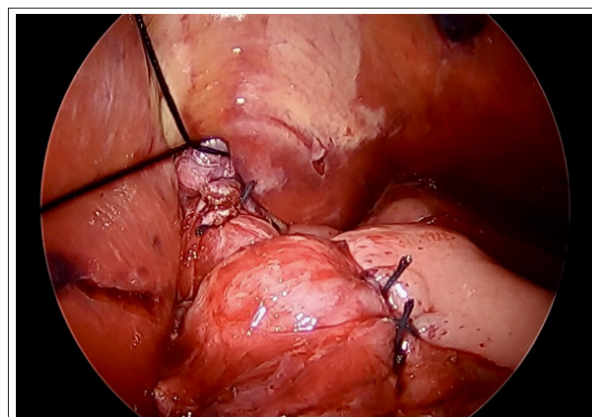


Figure 2: Image of Fundoplication with Membrane Reconstruction (Group B), Showing the Suture that Joins the 2 Layers of the phreno-esophageal Membrane to the Esophagus

Statistical Analysis

The counts and percentages were calculated for the categorical variables, and corresponding bar graphs were created. Mean and standard deviation were calculated for numerical variables, as well as minimum and maximum. The X2 independence test was applied to determine the association between the type of cohort and the variables of interest. In addition, the Odds Ratio (OR) was calculated, along with its respective 95% confidence interval (CI), to determine the size of the association between fundoplication migration and the type of cohort. Values of $p \leq 0.05$ were considered significant. The analysis was performed using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, NY, USA).

Results

During the studied period, 690 patients underwent Nissen fundoplication by laparoscopy, with information available on 631 children. The data of these patients were analyzed, of which 52.1% belonged to group A, treated from 2013 to 2018, in whom membrane reconstruction was not performed. The remaining 47.9% belonged to group B, treated from 2019 to 2023, in whom membrane reconstruction was performed.

The most frequent sex in both groups was female, with 55.3% in group A and 58.5% in group B. ($p=0.417$)

Regarding age, a lower mean age was found in group A compared to group B (60.2 months vs 87.7 months). The age group most frequently included in group A was preschool age, with 48.9%, while in group B, the most frequent age group was school age, with 64.2%. ($p<0.001$) The main symptoms were grouped into respiratory, digestive, and neurological damage.

Respiratory symptoms occurred in 53.2% of patients in group A, while in group B they occurred in 62.9%. ($p=0.013$).

Digestive symptoms occurred in 21.3% of patients in group A and in 18.9% of patients in group B. ($p=0.452$)

Patients with neurological damage accounted for 25.8% of patients in group A and 18.2% of children in group B. ($p=0.021$). (Table 1)

Table 1: Presence of Respiratory, Neurological, and Digestive Symptoms by Group

Symptoms	Group A (no repair) n (%)	Group B (repair) n (%)	Total n (%)	p value
Respiratory Symptoms	175 (53.2)	190 (62.9)	365 (57.8)	0.013
No	154 (46.8)	112 (37.1)	255 (42.2)	
Neurological Symptoms	85 (25.8)	55 (18.2)	140 (22.2)	0.021
No	244 (74.2)	247 (81.8)	491 (77.8)	
Digestive Symptoms	70 (21.3)	57 (18.9)	127 (20.1)	0.452
No	259 (78.7)	245 (81.1)	504 (79.9)	

a. X^2 Independence Test

Transient dysphagia occurred in 19.8% of patients in group A and in 29.1% of patients in group B. ($p=0.006$). Severe dysphagia, defined as requiring a new surgery, occurred in 1.2% of children in group A and 1.7% of patients in group B. ($p=0.642$)

The mean surgical time was shorter in group A compared to group B, at 67.2 minutes versus 84.2 minutes. ($p<0.001$)

Fundoplication migration occurred in 7.0% of patients in Group A, and in 1.3% of children in Group B. ($p<0.001$). An 82.1% reduction in the odds of presenting fundoplication migration was observed in Group B compared to Group A (OR 0.179, 95% CI 0.06-0.52). (Table 2)

Table 2: Fundoplication Migration by Group

	Group A (no repair) n (%)	Group B (repair) n (%)	Total n (%)	OR (95% CI)	p value
Migration of Fundoplication	23 (7.0)	4 (1.3)	27 (4.3)	0.179 (0.06-0.52)	<0.001
No Migration	306 (93.0)	298 (98.7)	604 (95.7)		
Total	329 (52.1)	302 (47.9)	631 (100)		

a. X^2 Independence Test

† Migration time (months): Minimum =12, maximum =76, mean = 26, SD=14

All patients who had intrathoracic migration presented recurrence of reflux symptoms, so they underwent, at this time, a contrast study and an endoscopy that confirmed this complication. (Figure: 3 and 4. X-ray and endoscopy)



Figure 3: Radiological Image with Contrast Material showing the Presence of the Stomach above the Diaphragm Compatible with a paraesophageal Hernia



Figure 4: Retrospective Endoscopic Image showing a paraesophageal Hernia

The mean migration time in group A was 37.6 months, while in group B, with membrane reconstruction, it was 27.0 months. ($p=0.166$)

Discussion

Nissen fundoplication is a procedure frequently performed in children to control gastroesophageal reflux [1].

The appropriate technique requires identifying the esophagogastric junction and obtaining an adequate segment of abdominal esophagus, for which it is necessary to incise the phrenoesophageal ligament [2].

Transthoracic migration of the fundoplication is a frequent complication; its etiopathogenesis is unknown, and attempts have been made to prevent it using mesh, sutures of the fundus to the diaphragmatic muscle, or by minimal esophageal dissection, without achieving a decrease in this migration, since it continues to occur in up to 12% of patients [3-11].

In a review of the characteristics found in the new surgeries of these patients, it was found that migration occurs in 90% of children in the anterior part of the hiatus. This place corresponds to the site of the phrenoesophageal membrane, and in the rest of the patients, as this complication is due to the presence of a short esophagus [12].

Although Allison suggested reconstruction of this membrane at the time of antireflux surgery in 1951, it is not part of the Nissen fundoplication technique [2-13].

In this research, we found that reconstruction of the phrenoesophageal membrane during laparoscopic Nissen fundoplication in children decreases the frequency of transthoracic migration to less than 2%.

The phrenoesophageal membrane is a fold of peritoneum and pleura that prevents communication between the thorax and the abdomen and should not be confused with the diaphragm muscle. It is crucial to identify this membrane to reconstruct the peritoneal extension towards the esophagus and avoid facing the diaphragm in the anterior part of the hiatus, in order not to promote dysphagia by trapping the esophagus in the diaphragm. Till et al. recommend placing a suture in the anterior part of the hiatus, and with this, they manage to face the phreno-esophageal membrane and avoid the migration of the fundoplication [18].

In this work, we found that membrane reconstruction does not increase the possibility of dysphagia. However, this repair

increases the time of surgery, but it does not cause morbidity for the patient.

A decrease in transthoracic migration has also been documented in adult patients undergoing hiatal surgery after phrenoesophageal membrane repair [19].

Strengths and Limitations of the Study

The retrospective nature of our study introduces inherent biases, including a potential selection bias and the lack of control over all confounding factors. We also acknowledge age differences within the cohort groups as an underlying bias that can lead to statistical differences.

Despite these limitations, the uniformity of our surgical team and technique strengthens the internal validity of our findings.

The reduction of intrathoracic migration of the fundoplication, along with the safety of the phrenoesophageal ligament repair, makes the reconstruction of the phrenoesophageal membrane an easy and reproducible alternative to avoid this complication.

Future research should be conducted through prospective studies with larger and more diverse populations to validate the findings of this study.

Conclusion

Phrenoesophageal ligament reconstruction is a safe procedure that reduces the risk of postoperative transthoracic migration in children undergoing laparoscopic Nissen fundoplication.

Declarations / Compliance with Ethical Standards Funding

This work did not receive any funding.

Competing Interests

The authors declare that they have no conflicts of interest. Ethics approval: This study was approved by the hospital's Teaching and Research Committee (approval number: [insert number/folio if available]). Informed consent: Written informed consent was obtained from the legal guardians of all participants included in the study.

Data Availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Dr. García-Hernández, Dra. Carvajal-Figueroa, Dra Alvelais-Arzamendi, Dr Landa-Juarez, Dr Aguilar-Gutierrez and Dr Herrera-Ojeda have no conflicts of interest to disclose. All authors read and approved the final manuscript.

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