



Laparoscopic Heller Myotomy for Pediatric Esophageal Achalasia: Lessons Learned from a 25-Year Single-Center Experience

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Abstract

Background: Esophageal achalasia is a rare primary motility disorder in childhood, and evidence guiding the optimal surgical approach remains limited, particularly regarding the role of intraoperative endoscopy and the choice of fundoplication. The aim was to describe a 25-year single-center experience with laparoscopic Heller myotomy in children with esophageal achalasia and to identify technical factors associated with favorable outcomes and prevention of complications.

Methods: A retrospective descriptive study at a tertiary pediatric hospital between 2000 and 2025. Consecutive patients younger than 18 years who underwent laparoscopic Heller myotomy for esophageal achalasia were eligible. Complete clinical and follow-up data were available for 31 of 36 operated patients. All procedures were performed by the same dedicated pediatric minimally invasive surgery team using a standardized approach including laparoscopic myotomy, routine intraoperative endoscopy, and posterior Toupet fundoplication.

Results: Thirty-six children underwent laparoscopic surgery for achalasia, and 31 were available for full analysis. Mean age at surgery was 11.9 ± 3.8 years. Three mucosal perforations (8.3%) were identified intraoperatively, all in previously treated patients, and all were repaired laparoscopically without conversion. Mean operative time was 94.6 minutes, and postoperative hospital stay ranged from 3 to 6 days. The Eckardt score improved from 2.78 preoperatively to 0.22 at 6 months and 0.07 at 12 months ($p < 0.001$). Clinical success at 12 months was achieved in 30 of 31 patients (96.8%).

Conclusion: Laparoscopic Heller myotomy with routine intraoperative endoscopy and posterior Toupet fundoplication appears to be a safe and effective treatment for pediatric achalasia in specialized centers.

Keywords: Achalasia; Heller Myotomy; Intraoperative Endoscopy; Laparoscopy; Pediatric Surgery

Introduction

Esophageal achalasia is a primary motility disorder characterized by impaired relaxation of the lower esophageal sphincter and absent peristalsis of the esophageal body, and it is rare in childhood, with an estimated incidence of around 0.11 per 100,000 children. In pediatric patients, progressive dysphagia, regurgitation, chest pain, weight loss, and recurrent respiratory symptoms frequently lead to delayed diagnosis, with significant nutritional and pulmonary morbidity [1,2]. Therapeutic strategies aim to reduce lower esophageal sphincter pressure and have evolved from pneumatic dilatation and open cardiomyotomy to minimally invasive approaches. Laparoscopic Heller myotomy, usually combined with a partial fundoplication, is currently regarded as the preferred treatment in most children, based on retrospective series and expert guidelines suggesting superior long-term symptom control compared with endoscopic dilatation. However, several technical aspects remain debated, including the optimal distal extent of the myotomy, the role of intraoperative endoscopy, and the most appropriate type of fundoplication to balance dysphagia relief against gastroesophageal reflux [3]. In recent years, Peroral Endoscopic Myotomy (POEM) has emerged as an alternative to laparoscopic Heller myotomy, with growing experience in adults and an increasing, although still limited, number of reports in the pediatric population. Nevertheless, current international recommendations continue to consider surgical myotomy, either laparoscopic or endoscopic, as the preferred first-line option in children with idiopathic achalasia, particularly those older than five years, emphasizing the need for treatment in specialized centers. In this setting, evidence in children is largely based on single-center case series with relatively small sample sizes and heterogeneous technical details, and long-term outcomes beyond the early postoperative period remain incompletely characterized [3,4]. The systematic use of intraoperative endoscopy during laparoscopic Heller myotomy has been proposed to ensure adequate distal extension, confirm completeness of the myotomy, and allow early detection of mucosal perforation, but pediatric data are scarce and often embedded within mixed adult–pediatric cohorts [5,6]. Likewise, the choice between a posterior Toupet and an anterior Dor fundoplication in children is not clearly supported by high-quality comparative studies, and practice is largely driven by institutional experience [3,7]. The aim of this study was to describe a 25-year single-center experience in the management of pediatric esophageal achalasia using standardized laparoscopic Heller myotomy with routine intraoperative endoscopy and posterior Toupet fundoplication, focusing on key technical aspects, complications, and clinical outcomes as assessed by the Eckardt score.

Materials and Methods

Study Design and Patients

This was a retrospective descriptive study conducted at a tertiary pediatric hospital between January 2000 and December 2025. Data were obtained from paper medical records and operating room reports, which were systematically reviewed using a predefined data extraction form. All consecutive patients younger than 18 years with a diagnosis of esophageal achalasia who underwent laparoscopic Heller myotomy during the study period were eligible for inclusion. Diagnosis was established based on clinical presentation and a multimodal work-up including upper gastrointestinal endoscopy and contrast esophagography; esophageal manometry was performed when available. During the study period, 36 children underwent laparoscopic surgery for esophageal achalasia. Complete clinical and follow-up data were available for 31 patients, who constituted the analytic cohort for detailed demographic, clinical, and outcome analyses. Patients with incomplete charts or follow-up shorter than 6 months were excluded from the main outcome analysis. All procedures were performed at a single center by the same dedicated pediatric minimally invasive surgery team, ensuring a consistent surgical approach and minimizing inter-surgeon variability over the 25-year period.

Surgical Technique

A standardized surgical technique was applied in all cases by the same pediatric surgical team. After establishment of pneumoperitoneum, a four-port laparoscopic approach was used to expose the distal esophagus and esophagogastric junction. The distal esophagus was mobilized circumferentially to obtain wide exposure of the anterior esophageal wall. The myotomy was performed using a harmonic scalpel, starting approximately 4 a 5 cm above the esophagogastric junction (Figure 1) and extending 2–3 cm onto the gastric cardia. (Figure 2) Intraoperative upper endoscopy was systematically used in all patients. Endoscopic transillumination guided the distal extent of the myotomy and allowed real-time assessment of mucosal integrity (Figure 3). After completing the myotomy, air insufflation under saline irrigation was performed to detect occult mucosal perforations; when identified, mucosal tears were repaired laparoscopically with interrupted sutures, without the need for conversion to open surgery. To prevent gastroesophageal reflux while avoiding obstruction of the myotomy, a posterior Toupet hemifundoplication was routinely constructed by wrapping the gastric fundus 270° around the posterior aspect of the distal esophagus and securing it with interrupted non-absorbable sutures. In patients referred after previous antireflux or myotomy procedures, adhesiolysis and careful identification of distorted anatomy were performed before completing the standardized myotomy and posterior

fundoplication.

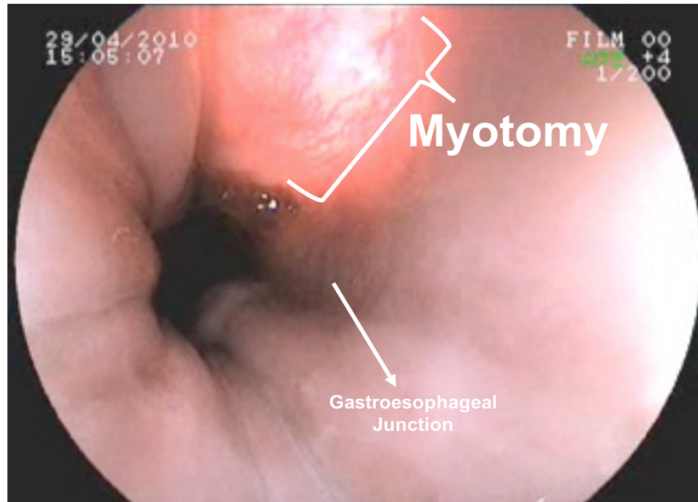


Figure 1: Intraoperative endoscopic image showing transillumination of the esophageal segment of the myotomy above the esophagogastric junction, confirming its proximal extent.

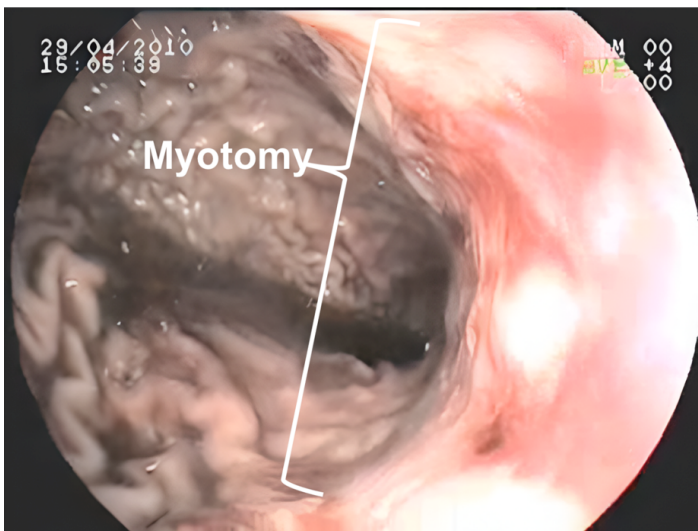


Figure 2: Intraoperative endoscopic image showing transillumination of the distal myotomy, approximately 2 cm below the esophagogastric junction.

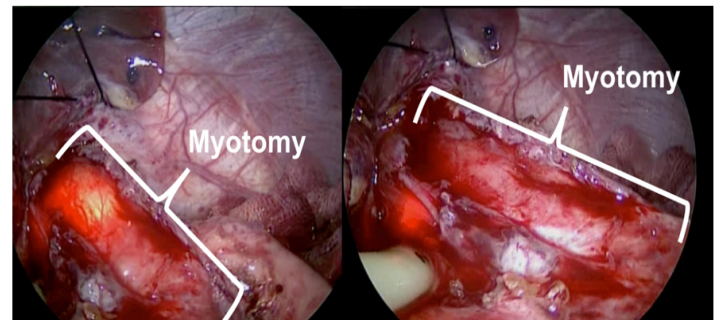


Figure 3: Laparoscopic view of the esophageal and gastric components of the myotomy. The esophageal myotomy extends approximately 4 cm proximally, and the distal gastric myotomy is shown on the right. The esophageal mucosa appears intact.

Data Collection and Outcomes

Demographic and clinical variables included age at surgery, sex, age group, symptom duration, predominant symptoms, associated conditions, and previous medical, endoscopic, or surgical treatments. Diagnostic variables comprised findings on contrast esophagram, upper gastrointestinal endoscopy, and esophageal manometry when available. Perioperative variables included operative time, intraoperative complications, need for conversion to open surgery, and postoperative hospital stay. Symptom severity was assessed using the Eckardt score, which grades dysphagia, regurgitation, chest pain, and weight loss from 0 to 3, yielding a total score ranging from 0 to 12. The Eckardt score was recorded preoperatively and at 6 and 12 months after surgery during routine outpatient visits or structured telephone interviews. Clinical success was defined a priori as an Eckardt score ≤ 3 at 12 months without the need for additional invasive treatment. Treatment failure was defined as an Eckardt score >3 or the requirement for reintervention due to persistent or recurrent symptoms.

Statistical Analysis

Continuous variables are presented as mean $\pm$ standard deviation or median (interquartile range), depending on distribution, and categorical variables as absolute numbers and percentages. Preoperative and postoperative Eckardt scores were compared using the Wilcoxon signed-rank test for paired data. A two-sided p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Review Board of Hospital Star Médica Infantil Privado. Given the retrospective design and the use of de-identified data obtained from existing paper medical records, the requirement for individual informed consent was waived, in accordance with the Declaration of Helsinki and applicable local regulations. All data were handled confidentially, and no information that could directly identify individual patients was collected in the study database. All surgical procedures were performed according to standard clinical practice, after obtaining written informed consent for surgery from the parents or legal guardians.

Results

Between January 2000 and December 2025, 36 patients younger than 18 years underwent laparoscopic surgery for esophageal achalasia at our institution. Complete clinical and follow-up data were available for 31 patients, who constituted the analytic cohort. Among these 31 patients, 17 were female (54.8%) and 14 were male (45.2%). Age at surgery ranged from 1 to 18 years, with a mean age of 11.9 ± 3.8 years; school-aged children and adolescents were the most frequent age groups, each representing 44.4% of the cohort. Progressive dysphagia was present in all patients (100%). Retrosternal pain during feeding was reported in 59.3% of patients, heartburn in 11.1%, nocturnal cough in 59.3%, and weight loss in 77.8%. Symptom duration ranged from 3 to 42 months, with a mean duration of 17.4 ± 10.7 months; in 55.6% of children, symptoms had been present for more than 12 months before diagnosis. Two patients (6.45%) had associated conditions: a 9-year-old child with Down syndrome and the youngest patient, under 1 year of age, who had Allgrove syndrome. Previous treatment was common. Medical therapy with prokinetics and acid-suppressive drugs had been administered in 66.7% of patients. Pneumatic dilatation had been performed in 22.6%, with only transient improvement and recurrence of symptoms within 6 months. Five children (16.1%) had undergone prior surgical treatment. In three of these patients, persistent symptoms were due to incomplete myotomy and required a wider revisional myotomy, including two children previously treated by thoracotomy and one with a prior laparoscopic myotomy. In the remaining two patients, dysphagia was related to a malpositioned anterior fundoplication (Dor) documented on endoscopy, and symptom resolution required correction of the wrap without extension of the myotomy. (Figure 4) The diagnostic work-up in the 31 patients with complete records included contrast esophagram and upper gastrointestinal endoscopy in all cases. The contrast study consistently demonstrated esophageal dilatation with smooth, symmetric narrowing toward the esophagogastric junction, with food retention in some patients.

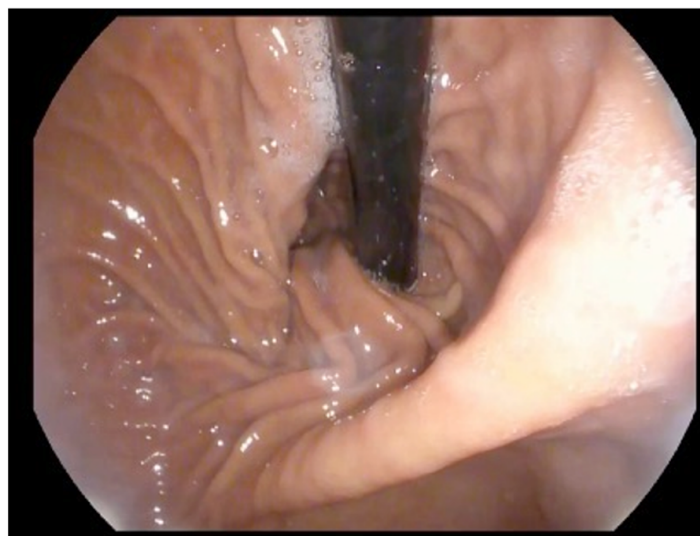


Figure 4: Endoscopic image from the same patient, showing a displaced flap of the Dor fundoplication encroaching on the lumen and impairing esophageal emptying.

Upper endoscopy confirmed esophageal dilatation with retained saliva and food, concentric mucosal folds, and lack of cardia relaxation with air insufflation, while allowing easy passage of the endoscope into the stomach. Esophageal manometry was performed in 22 patients (71.0%); 16 showed impaired relaxation of the lower esophageal sphincter with absent peristalsis, whereas 6 studies were inconclusive. In the remaining 9 children (29.0%), manometry could not be performed due to lack of equipment or poor cooperation, and the diagnosis was established based on clinical, radiologic, and endoscopic findings. All patients underwent laparoscopic esophageal myotomy with intraoperative endoscopic assistance. No complications related to intraoperative endoscopy were observed. Intraoperative endoscopy allowed immediate detection of mucosal perforation at the myotomy site in three patients, corresponding to 9.6 % of the total surgical cohort. Two of these perforations occurred in patients previously treated with pneumatic dilatation and one in a patient with prior surgery, suggesting greater tissue fragility and technical difficulty in previously manipulated esophagogastric junctions. All perforations were recognized intraoperatively and repaired laparoscopically, without conversion to open surgery. The mean operative time was 94.6 minutes, and postoperative hospital stay ranged from 3 to 6 days. Symptom severity, as measured by the Eckardt score, improved markedly after surgery. The mean preoperative Eckardt score was 2.78 and decreased to 0.22 at 6 months and 0.07 at 12 months, showing a statistically significant improvement compared with baseline ($p < 0.001$). Clinical success, defined as an Eckardt score ≤ 3 at 12 months without the need for additional invasive

treatment, was achieved in 30 of 31 patients (96.8%) with available follow-up. These findings indicate that laparoscopic Heller myotomy with routine intraoperative endoscopy and posterior partial fundoplication provided durable symptom relief in the vast majority of children in this single-center series (Table 1).

Variable	Value
Diagnostic work-up	
Patients with complete records	31
Contrast esophagram performed	31 (100%)
Upper GI endoscopy performed	31 (100%)
Esophageal manometry performed	22 (71.0%)
Diagnostic manometry	16/22
Inconclusive manometry	Jun-22
Manometry not performed	9 (29.0%)
Intraoperative findings	
Intraoperative endoscopy-related complications	0%
Mucosal perforation at myotomy site	3/36 (8.3%)
Conversion to open surgery	0%
Mean operative time, minutes	94.6
Postoperative hospital stay, days	03-Jun
Clinical outcomes	
Preoperative Eckardt score, mean	2.78
Eckardt score at 6 months, mean	0.22
Eckardt score at 12 months, mean	0.07
p-value (preop vs 6 and 12 months)	<0.001
Clinical success at 12 months (Eckardt <=3)	30/31 (96.8%)

Data are presented as n, n (%), n/N, or mean. Mucosal perforations are expressed relative to the total surgical cohort (n = 36). Eckardt scores were compared using the Wilcoxon signed-rank test. Clinical success was defined as an Eckardt score <=3 at 12 months without additional invasive treatment.

Table 1: Diagnostic work-up, intraoperative findings, and clinical outcomes after laparoscopic Heller myotomy with intraoperative endoscopy and posterior partial fundoplication.

Discussion

This study summarizes a 25-year single-center experience with laparoscopic Heller myotomy, routine intraoperative endoscopy, and posterior Toupet fundoplication for pediatric esophageal achalasia. The main findings are the high rate of clinical success at 12 months (30/31, 96.8%), the marked reduction in Eckardt score after surgery, the absence of conversion to open surgery, and the ability of intraoperative endoscopy to identify and allow

immediate repair of mucosal perforations. Together, these results support laparoscopic Heller myotomy as a safe and effective treatment option for children with achalasia when performed in specialized centers [1,2,8]. The symptom profile observed in this series is consistent with previous pediatric reports, in which progressive dysphagia is the dominant presenting complaint and is frequently accompanied by weight loss, retrosternal discomfort, and respiratory symptoms. The prolonged mean symptom duration before diagnosis in the present cohort also underscores the well-recognized difficulty of identifying achalasia early in children, particularly in settings where access to manometry is limited. More than half of the patients had symptoms for longer than 12 months before diagnosis, highlighting the need for a high index of suspicion in children with persistent dysphagia, poor weight gain, or recurrent nocturnal respiratory symptoms [3,4]. A relevant contribution of this study is the standardized use of intraoperative endoscopy in all procedures. In this cohort, endoscopy was useful not only to confirm the distal extent and completeness of the myotomy, but also to detect mucosal perforations immediately, allowing prompt laparoscopic repair without conversion. Importantly, all three mucosal perforations occurred in previously treated patients, two after pneumatic dilatation and one after prior surgery, suggesting that prior manipulation of the esophagogastric junction increases technical difficulty and tissue fragility. This observation is clinically relevant because redo procedures and previously instrumented patients may benefit particularly from a strategy combining meticulous laparoscopic dissection with routine endoscopic guidance [5]. An additional practical lesson from this series is that persistent dysphagia after previous surgery should not automatically be attributed to incomplete myotomy. Among the five children referred after prior surgical treatment, three had persistent symptoms due to incomplete myotomy and required extension of the myotomy, whereas in two the cause was a malpositioned anterior Dor fundoplication and symptom resolution required correction of the wrap without extending the myotomy. These findings emphasize the importance of careful preoperative and intraoperative evaluation to distinguish between persistent outflow obstruction caused by inadequate myotomy and mechanical obstruction caused by an incorrectly positioned fundoplication, since the surgical solution differs substantially in each scenario. The routine use of a posterior Toupet fundoplication is another distinctive feature of this series. Although high-quality comparative pediatric data remain limited, partial fundoplication after Heller myotomy is generally used to reduce postoperative reflux while avoiding obstruction caused by an overly tight wrap. In the present cohort, the combination of myotomy, endoscopic confirmation, and posterior partial fundoplication was associated with excellent symptom relief and a short postoperative hospital stay of 3 to 6 days, supporting the practical effectiveness of this technical strategy. At the same time, the existing pediatric

literature has not definitively established the superiority of Toupet over Dor fundoplication, and the choice often depends on surgeon preference and institutional experience. The outcomes observed in this study compare favorably with the available pediatric literature, which is still composed mainly of retrospective single-center series and expert recommendations rather than randomized comparative studies. The 96.8% clinical success rate at 12 months and the substantial reduction in Eckardt score indicate durable short-term control of obstructive symptoms. These findings remain relevant in the current era, in which Peroral Endoscopic Myotomy (POEM) has emerged as an alternative minimally invasive treatment. Although pediatric experience with POEM is increasing and early outcomes are encouraging, current evidence still supports both laparoscopic Heller myotomy and POEM as valid options in specialized centers, and the present results confirm that laparoscopic Heller myotomy remains a highly effective approach [1-4,8].

This study has several strengths. It represents a relatively large pediatric single-center experience in a rare disease, reflects a long institutional learning period, and reports the results of a standardized technique performed by the same dedicated minimally invasive surgery team. The systematic use of intraoperative endoscopy in all patients is another important strength, because it allowed consistent technical verification and immediate management of mucosal injuries. In addition, postoperative outcomes were assessed using the Eckardt score, providing an objective and reproducible measure of symptom improvement over time [9-11]. The study also has important limitations. Its retrospective design makes it vulnerable to missing data and information bias, particularly because the study period extended over 25 years and relied on paper medical records. Although 36 patients underwent surgery, complete records were available for only 31, which may have limited the precision of some clinical estimates. The long inclusion period also implies potential temporal changes in perioperative care, diagnostic resources, and surgical learning curve, even though procedures were performed by the same team. In addition, the absence of a comparison group precludes direct conclusions regarding superiority over other strategies such as pneumatic dilatation, Dor fundoplication, or POEM. Finally, reflux outcomes were not systematically assessed with pH monitoring or endoscopic surveillance, so the antireflux efficacy of the Toupet fundoplication cannot be fully characterized [1]. Despite these limitations, the findings provide useful long-term institutional experience in a rare pediatric disorder and reinforce several practical lessons: achalasia in children requires a multimodal diagnostic approach, previous treatment increases operative complexity, and routine intraoperative endoscopy can improve the safety and completeness of laparoscopic myotomy. Future multicenter studies with standardized outcome reporting, longer follow-up, and direct comparison with endoscopic alternatives

will be necessary to better define the optimal first-line treatment for pediatric achalasia.

Conclusion

In this 25-year single-center experience, laparoscopic Heller myotomy with routine intraoperative endoscopy and posterior Toupet fundoplication was associated with a high rate of clinical success and substantial symptom improvement in children with esophageal achalasia. The systematic use of intraoperative endoscopy facilitated confirmation of myotomy completeness and immediate detection and repair of mucosal perforations, particularly in previously treated patients. In previously operated children, persistent dysphagia may reflect either incomplete myotomy or mechanical obstruction from a malpositioned fundoplication, and differentiating between these mechanisms is essential to guide the appropriate revisional procedure. These findings support laparoscopic Heller myotomy as a safe and effective treatment option for pediatric achalasia in specialized centers, while highlighting the need for multicenter comparative studies with standardized long-term assessment of reflux and functional outcomes.

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