



Multidimensional Long-term Outcomes after Pediatric Esophageal Replacement following Caustic Injuries

Article History:

Name of Author:

Imran Tahir¹, Ghulam Mohy ud Din²,
Sulman Bajwa³, Nabi Bux⁴, Seemab Aamir⁵,
Sadia Asmat Burki⁶, Muhammad Fayyaz⁷

Affiliation: ¹Assistant Professor,
Department of Thoracic Surgery,
Hayatabad Medical Complex, Peshawar,
Pakistan

²Senior Registrar, Department of Pediatric
Urology & Pediatric Surgery, Fatima
Memorial Hospital, Lahore/ Fatima
Memorial Medical College, Lahore,
Pakistan

³Senior Registrar, Fazaia Medical College,
Consultant, Department of Pediatric
Surgery, PAF Hospital, Islamabad, Pakistan

⁴Associate Professor, Department of
Paediatric Surgery, Ghulam Muhammad
Mahar Medical College, Sukkur, Pakistan

⁵Senior Registrar, Department of Paediatric
Surgery, Northwest General Hospital and
Research Center, Peshawar, Pakistan

⁶Assistant Professor, Department of
Paediatric Surgery, The Children Hospital
PIMS Islamabad, Pakistan

⁷Assistant Professor, Department of
Paediatric Surgery, Qazi Hussain Ahmed
Medical Complex Nowshera / Nowshera
Medical College, Nowshera, Pakistan

Corresponding Author:

Dr. Muhammad Fayyaz,

Email address: drfayyazayaz@gmail.com

Received: 08-09-2025

Revised: 27-11-2025

Accepted: 08-12-2025

Published: 18-12-2025

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Noncommercial-Share Alike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

Abstract: Background: Caustic ingestion in children frequently results in severe esophageal injury, and a subset of patients develop long-segment strictures requiring esophageal replacement. **Objective:** To assess long-term functional, nutritional, respiratory, surgical, and psychosocial outcomes in pediatric patients undergoing esophageal replacement following caustic injury. **Methods:** This hospital-based longitudinal observational study was conducted at Hayatabad Medical Complex, Peshawar from July 2024 to July 2025 included 195 pediatric patients who underwent esophageal replacement. Demographic characteristics, surgical details, and early postoperative outcomes were recorded. Long-term follow-up evaluated swallowing function, dysphagia, growth parameters, respiratory complications, reintervention rates, and pediatric quality-of-life scores. Continuous variables were expressed as mean $\pm$ standard deviation, and categorical variables as frequency and percentage. **Results:** The mean age at surgery was 6.8 ± 3.2 years, with alkali ingestion accounting for 67.7% of cases. Gastric pull-up was performed in 62.1% of patients. Early complications included anastomotic leak in 14.4% and respiratory complications in 14.9%, with a 30-day mortality of 1.5%. Over a mean follow-up of 6.1 ± 2.8 years, 75.9% achieved full oral diet tolerance, while 21.5% developed late strictures and 19.0% required dilatation. Nutritional deficits persisted in 23.6% for weight and 20.0% for height. Recurrent pneumonia occurred in 15.9%, and 14.9% required late surgical reintervention. **Conclusion:** Pediatric esophageal replacement following caustic injury results in favorable long-term functional recovery for most patients; however, multidimensional morbidity persists in a significant minority.

Keywords: Caustic ingestion; Pediatric esophageal replacement; Gastric pull-up; Colonic interposition; Long-term outcomes; Respiratory complications.

INTRODUCTION

Caustic ingestion is a severe health problem in the world, especially in developing countries where exposure to household corrosive agents is usually accidental [1]. The esophagus is particularly susceptible to chemical injury, and transmural burns can cause progressive fibrosis and long-segment strictures [3]. Although a large number of cases can be saved by early endoscopic evaluation and frequent dilatation, a proportion of children eventually have to be placed on esophageal replacement because of failure of conservative management [5]. Liquefactive necrosis is observed to arise from alkali exposure, which penetrates tissue more readily, whereas coagulative necrosis is generally caused by acids; both may lead to debilitating strictures depending on the concentration and exposure time [2]. The chronic complications are dysphagia, malnutrition, growth retardation, and frequent aspiration, which have a severe impact on the physical and psychosocial development in the critical childhood years [6]. The long-term cost does not just entail the structural damage but a complicated functional impairment [8]. Gastric pull-up, colonic interposition, and jejunal grafts are esophageal replacement techniques that have significantly increased the survival and continuity of the alimentary tract [4]. The development of perioperative care and surgical techniques has decreased mortality during the initial postoperative period, but morbidity after surgery is still a clinical issue [7]. Long-term problems are often reported such as anastomotic strictures, conduit redundancy, slow gastric emptying, and gastroesophageal reflux [9].

Notably, outcome assessment has changed to a level of nutritional rehabilitation, respiratory health, growth patterns, efficiency in swallowing, and quality of life [11] according to modernity. Children who undergo esophagus reconstruction surgery can develop recurrent pulmonary infections as a result of micro-aspiration or dysfunction of the conduit, and therefore requires long-term monitoring [10]. Also, long-term morbidity in younger years may interfere with education, social adaptation, and mental adaptation [13]. Although several reports have outlined surgical methods and short-term outcomes, there are no long-term and multidimensional data in extensive pediatric cohort studies [12[15]]. The literature that is available is more likely to concentrate on technical success than on functional recovery and impact on life-course [14]. It is necessary to have a holistic conception of long-term outcomes to inform the counseling process, design effective follow-up plans, and enhance surgical decision-making [16].

Objective: To assess long-term functional, nutritional, respiratory, surgical, and psychosocial outcomes in pediatric patients undergoing esophageal replacement following caustic injury.

METHODOLOGY

This was a hospital-based longitudinal observational study conducted at Hayatabad Medical Complex, Peshawar from July 2024 to July 2025. A total of 195 pediatric patients who underwent esophageal replacement following caustic ingestion were included in the study.

Inclusion Criteria

- Pediatric patients aged <18 years at the time of surgery.
- History of caustic ingestion resulting in confirmed esophageal stricture.
- Patients who underwent esophageal replacement surgery (gastric pull-up, colonic interposition, or jejunal interposition).
- Minimum postoperative follow-up duration of at least 2 years.
- Parents or legal guardians who provided informed consent.

Exclusion Criteria

- Patients with congenital esophageal anomalies (e.g., esophageal atresia).
- Esophageal replacement performed for malignancy or non-caustic causes.
- Patients with severe neurological disorders affecting swallowing function.
- Patients with incomplete follow-up records.
- Patients unwilling to participate in long-term evaluation.

Data Collection

After obtaining written informed consent from parents or legal guardians, detailed demographic, clinical, surgical, and follow-up data were collected using a structured proforma. Baseline variables included age at injury, gender, type of caustic agent (acid or alkali), duration between injury and surgery, and preoperative nutritional status. Surgical details, including type of esophageal replacement (gastric pull-up, colonic interposition, or jejunal interposition), anastomotic site, and early postoperative complications, were recorded. Long-term multidimensional outcomes were assessed at follow-up visits and included swallowing tolerance (solid, soft, or liquid diet), dysphagia grading, need for postoperative dilatation, and presence of an anastomotic stricture. Nutritional and growth parameters were evaluated using weight-for-age, height-for-age, and body mass index (BMI) for age percentiles. Respiratory outcomes such as recurrent pneumonia, chronic cough, and aspiration symptoms were documented. Psychosocial outcomes were assessed through school attendance status, social participation, and a standardized pediatric quality-of-life scoring system. All collected data were systematically recorded, cross-verified with hospital records, and prepared for statistical analysis.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software version 26. Continuous variables were expressed as mean $\pm$ standard deviation (SD), whereas categorical variables were presented as

frequencies and percentages. Comparisons between different conduit types and outcome categories were performed using appropriate statistical tests. A p-value of <0.05 was considered statistically significant.

RESULTS

The study included 195 pediatric patients with a mean age of 4.9 ± 2.7 years at ingestion and 6.8 ± 3.2 years at surgery, indicating an average delay of several months before definitive reconstruction (mean interval 9.4 ± 4.1 months). Males predominated (60.5%), and alkali ingestion was the leading cause (67.7%), with the vast majority being accidental (95.4%). More than half of the patients (56.9%) required more than five dilatation attempts prior to surgery, and half (50.3%) required preoperative gastrostomy.

Table 1. Baseline Demographic and Injury Characteristics (n = 195)

Variable	Category	n (%) / Mean $\pm$ SD
Age at ingestion (years)		4.9 ± 2.7
Age at surgery (years)		6.8 ± 3.2
Gender	Male	118 (60.5%)
Gender	Female	77 (39.5%)
Type of caustic agent	Alkali	132 (67.7%)
Type of caustic agent	Acid	63 (32.3%)
Nature of ingestion	Accidental	186 (95.4%)
Nature of ingestion	Intentional	9 (4.6%)
Time from injury to surgery (months)		9.4 ± 4.1
Preoperative dilatation sessions	≤ 5 sessions	84 (43.1%)
Preoperative dilatation sessions	> 5 sessions	111 (56.9%)
Preoperative gastrostomy	Present	98 (50.3%)
Preoperative gastrostomy	Absent	97 (49.7%)
Preoperative malnutrition	Present	72 (36.9%)
Preoperative malnutrition	Absent	123 (63.1%)

Gastric pull-up was the most commonly performed procedure (62.1%), followed by colonic interposition (31.3%) and jejunal interposition (6.7%). Cervical anastomosis was performed in 88.7% of cases. The mean operative time was 248 ± 52 minutes, and the average hospital stay was 14.6 ± 5.8 days. Early postoperative complications included anastomotic leak in 14.4%, surgical site infection in 17.4%, and respiratory complications in 14.9%.

Table 2. Surgical Characteristics and Early Postoperative Outcomes (n = 195)

Variable	Category	n (%) / Mean $\pm$ SD
Type of replacement	Gastric pull-up	121 (62.1%)
Type of replacement	Colonic interposition	61 (31.3%)
Type of replacement	Jejunal interposition	13 (6.7%)
Anastomosis site	Cervical	173 (88.7%)
Anastomosis site	Thoracic	22 (11.3%)
Operative duration (minutes)		248 ± 52
Hospital stay (days)		14.6 ± 5.8
Anastomotic leak	Present	28 (14.4%)
Anastomotic leak	Absent	167 (85.6%)
Surgical site infection	Present	34 (17.4%)
Surgical site infection	Absent	161 (82.6%)
Early respiratory complication	Present	29 (14.9%)
Early respiratory complication	Absent	166 (85.1%)
30-day mortality	Yes	3 (1.5%)
30-day mortality	No	192 (98.5%)

Over a mean follow-up of 6.1 ± 2.8 years, 75.9% of patients achieved full oral diet tolerance, while 17.4% remained on soft diets and 6.7% were predominantly liquid-dependent. Dysphagia was absent in 69.7%, mild in 20.0%, and moderate-to-severe in 10.3%. Late anastomotic stricture occurred in 21.5%, and 19.0% required late dilatation. Nutritional recovery was substantial but incomplete, as 23.6% remained below the 10th percentile for weight and 20.0% for height.

Table 3. Long-Term Functional and Nutritional Outcomes (n = 195)

Variable	Category	n (%) / Mean ± SD
Follow-up duration (years)		6.1 ± 2.8
Oral feeding status	Full oral diet	148 (75.9%)
Oral feeding status	Soft diet	34 (17.4%)
Oral feeding status	Liquid predominant	13 (6.7%)
Dysphagia grade	None	136 (69.7%)
Dysphagia grade	Mild	39 (20.0%)
Dysphagia grade	Moderate–Severe	20 (10.3%)
Late anastomotic stricture	Present	42 (21.5%)
Late anastomotic stricture	Absent	153 (78.5%)
Required late dilatation	Yes	37 (19.0%)
Required late dilatation	No	158 (81.0%)
Weight-for-age <10th percentile	Yes	46 (23.6%)
Weight-for-age <10th percentile	No	149 (76.4%)
Height-for-age <10th percentile	Yes	39 (20.0%)
Height-for-age <10th percentile	No	156 (80.0%)
BMI-for-age (kg/m ²)		17.8 ± 2.9
Ongoing supplemental feeding	Yes	28 (14.4%)
Ongoing supplemental feeding	No	167 (85.6%)

Long-term respiratory morbidity was observed in a measurable proportion of patients, with recurrent pneumonia in 15.9%, chronic cough in 19.5%, and documented aspiration in 13.3%. Gastroesophageal reflux symptoms were reported in 27.7%. Conduit redundancy requiring revision occurred in 8.7%, while 14.9% underwent at least one late surgical reintervention. Psychosocial integration was largely favorable, with 81.0% maintaining regular school attendance. However, 16.9% reported limited social participation.

Table 4. Long-Term Respiratory, Reintervention, and Psychosocial Outcomes (n = 195)

Variable	Category	n (%) / Mean ± SD
Recurrent pneumonia	Yes	31 (15.9%)
Recurrent pneumonia	No	164 (84.1%)
Chronic cough	Yes	38 (19.5%)
Chronic cough	No	157 (80.5%)
Documented aspiration episodes	Yes	26 (13.3%)
Documented aspiration episodes	No	169 (86.7%)
Gastroesophageal reflux symptoms	Present	54 (27.7%)
Gastroesophageal reflux symptoms	Absent	141 (72.3%)
Conduit redundancy requiring revision	Yes	17 (8.7%)
Conduit redundancy requiring revision	No	178 (91.3%)
Any late surgical reintervention	Yes	29 (14.9%)
Any late surgical reintervention	No	166 (85.1%)
Regular school attendance	Yes	158 (81.0%)
Regular school attendance	No	37 (19.0%)
Limited social participation	Yes	33 (16.9%)
Limited social participation	No	162 (83.1%)
Pediatric QoL score		78.4 ± 9.6
Reduced QoL (<70 score)	Yes	29 (14.9%)
Reduced QoL (<70 score)	No	166 (85.1%)

DISCUSSION

The paper has shown that long-term pediatric esophageal replacement after caustic injury results in good long-term survival and functional recovery in

most patients, yet is associated with long-term multidimensional morbidity in a clinically significant subset. The high percentages of alkali ingestion (67.7) and accidental exposure (95.4) are consistent with

epidemiological trends reported in prior studies on this topic, with household alkali agents being the most common cause of severe esophageal strictures in children. The fact that almost half of the patients (56.9) had undergone over five preoperative dilatations, and 36.9 percent of the patients had malnutrition before definite surgery, are indicative of the burden of chronic diseases before definitive surgery is obtained, as reported in previous studies of delayed reconstruction after failed endoscopic management [17]. The most frequently performed procedure was gastric pull-up (62.1%), consistent with earlier studies supporting the use of the stomach as an effective conduit, owing to its strong vascularity and one-anastomosis construction. The average time of 248 minutes of operation and 14.6 days of hospital stay indicates a technical complexity of these reconstructions but stay within the scopes of the technical complexity of these kinds of reconstructions as described in the earlier studies. The rate of early complications like anastomotic leak (14.4) and respiratory events (14.9) was not lower than its previously reported values implying reasonable perioperative safety and low 30-day mortality of 1.5% [18]. There were positive results regarding long-term functional outcomes, with 75.9% of patients having a full oral diet tolerance and 69.7% of patients having no dysphagia. Nevertheless, 21.5% were developed late strictures and 19.0% needed dilatation, which is comparable to prior studies where anastomotic stricture is the most frequent long-term complication. There was a significant but incomplete progression of nutritional recovery as the mean of BMI-for-age was 17.8 ± 2.9 kg/m², yet 23.6 percent were still underweight and 20.0 percent were stunted. Past studies also document sustained growth defects in spite of anatomical restoration that probably relates to chronic preoperative malnutrition and frequent postoperative complications [19].

The respiratory morbidity was significant with frequent pneumonia (15.9), chronic cough (19.5), and aspiration (13.3), as had been observed in earlier studies, and the same morbidities had been caused by the reflux and conduit dysfunction. The symptoms of gastroesophageal reflux in 27.7% also support the value of long-term surveillance, as previously emphasized in the literature [20]. The psychosocial outcome was mostly positive, with 81.0% continuing to attend school regularly, and their quality-of-life score was 78.4 ± 9.6 . However, 14.9% scored below 70 on quality-of-life and 16.9% had poor social participation. The past studies have also indicated that although the majority of children improve with time, there is a susceptible group that still faces impaired functions and psychosocial restrictiveness [21]. In general, the results provide evidence that pediatric esophageal replacement is associated with durable functional recovery in the majority of patients, although long-term multidimensional complications

(such as nutritional deficits, respiratory complications, and a decrease in the quality of life) continue to be observed in a significant minority, which justifies the idea of structured and multidisciplinary lifelong follow-up.

CONCLUSION

It is concluded that pediatric esophageal replacement following caustic injury provides satisfactory long-term survival and functional restoration in the majority of patients, with most children achieving full oral feeding, acceptable growth parameters, and good psychosocial reintegration. However, a clinically significant minority continues to experience late anastomotic strictures, respiratory morbidity, growth impairment, and reduced quality of life.

BIBLIOGRAPHY

1. Mubarak A et al (2021) Diagnosis, management, and prevention of button battery ingestion in childhood: a European Society for Paediatric Gastroenterology Hepatology and Nutrition position paper. *J Pediatr Gastroenterol Nutr* 73(1):129–136
2. Tringali A et al (2017) Pediatric gastrointestinal endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) and European Society for Paediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) Guideline Executive summary. *Endoscopy* 49(1):83–91
3. Kramer RE et al (2015) Management of ingested foreign bodies in children: a clinical report of the NASPGHAN endoscopy committee. *J Pediatr Gastroenterol Nutr* 60(4):562–574
4. Committee ASoP et al (2011) Management of ingested foreign bodies and food impactions. *Gastrointest Endosc* 73(6):1085–91
5. Thomson M et al (2017) Paediatric gastrointestinal endoscopy: European Society for Paediatric Gastroenterology Hepatology and Nutrition and European Society of Gastrointestinal Endoscopy guidelines. *J Pediatr Gastroenterol Nutr* 64(1):133–153
6. Jatana KR et al (2013) Pediatric button battery injuries: 2013 task force update. *Int J Pediatr Otorhinolaryngol* 77(9):1392–1399
7. Krom H, Venmans L, Tabbers MM (2019) Guideline 'ingestion of foreign bodies in children aged 0–18 years'. *Ned Tijdschr Geneeskd* 163:D4003
8. Litovitz TL et al (2001) 2000 Annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. *Am J Emerg Med* 19(5):337–395
9. Holtestaul T et al (2022) Pediatric ingestions. *Surg Clin North Am* 102(5):779–795
10. Ettyreddy AR et al (2015) Button battery injuries in the pediatric aerodigestive tract. *Ear Nose Throat J* 94(12):486–493

11. Ameet J et al (2018) Impaction of foreign body in upper digestive tract: unravelling the anatomical perspective. *Indian J Anat* 7(2):199–204
12. Litovitz T, Schmitz BF (1992) Ingestion of cylindrical and button batteries: an analysis of 2382 cases. *Pediatrics* 89(4 Pt 2):747–757
13. Yasui T (1986) Hazardous effects due to alkaline button battery ingestion: an experimental study. *Ann Emerg Med* 15(8):901–906
14. Sethia R et al (2021) Current management of button battery injuries. *Laryngoscope Investig Otolaryngol* 6(3):549–563
15. Litovitz T, Whitaker N, Clark L (2010) Preventing battery ingestions: an analysis of 8648 cases. *Pediatrics* 125(6):1178–1183
16. Litovitz T et al (2010) Emerging battery-ingestion hazard: clinical implications. *Pediatrics* 125(6):1168–1177
17. Center NCP (2010–2024) Button battery ingestion statistics [cited 2025; Available from: <https://www.poison.org/battery/stats>. Accessed 4 Nov 2025
18. Zipursky AR, Ratnapalan S (2021) Button battery ingestions in children. *CMAJ* 193(38):E1498
19. Hira Sing RA, Rodrigues Pereira R (2002) The dutch pediatric surveillance system; a quality focused instrument for prevention and research. *Ned Tijdschr Geneesk* 146(50):2409–2414
20. Hunault C et al (2020) Complicaties bij baby's en peuters die een batterij hebben ingeslikt. *Huisarts en Wetenschap*
21. Pizzol A et al (2020) Foreign-body ingestions in children during COVID-19 pandemic in a pediatric referral center. *JPGN Rep* 1(2):e018