Aim: This study aims to determine the sequelae of corrosive ingestion in children.

Methods: A retrospective study was conducted in the Department of Pediatric Surgery at a Tertiary Center. The children presenting between January 2015 and December 2020 with a history of ingestion of caustic agents were included in the study.

Results: A total of 26 children were included in the study. The children with suicidal attempts were significantly older than those who ingested the corrosive agents accidentally (14.2 ± 1.9 years vs. 6 ± 3.3 years; \( P < 0.01 \); Student’s \( t \)-test). Sixteen (62%) children had esophageal strictures, 8 (31%) had pyloric strictures, and a child (4%) had both esophageal and gastric strictures. Eight (31%) children required an initial feeding jejunostomy and 6 (23%) required a feeding gastrostomy as they had significant weight loss on presentation. Eleven (65%) esophageal strictures responded to the dilatation regimen and are symptom-free on follow-up. Three (18%) children with esophageal stricture underwent esophageal replacement. Eight (31%) children had a pyloric stricture and all of them were treated with a modified Billroth I gastro-duodenostomy. The children who presented after 2 months were found to have a significantly increased need for esophageal replacement (3/9 vs. 0/17; \( P = 0.03 \); Fischer’s exact test).

Conclusion: The corrosive ingestion in children is associated with higher morbidity. The sequelae include esophageal and antro-pyloric strictures. A feeding gastrostomy or jejunostomy was required in more than half of the patients. The children presenting after 2 months of ingestion were associated with an increased need for esophageal replacement.

KEYWORDS: Acid, alkali, corrosive ingestion, esophageal dilatation, esophageal stricture, gastric outlet obstruction

INTRODUCTION

Although uncommon, the ingestion of corrosive agents is associated with serious morbidity.[1] The corrosive injuries constitute one of the major causes of mortality in children <5 years of age.[2] The effects of corrosive agents vary from no obvious injury to life-threatening respiratory and gastrointestinal injuries.[3] The extent and severity of injuries depend on the nature and amount of the corrosive agent, and the duration of contact of the agent. The death rate varies from 0% to 12% and the rate of late esophageal stricture can be up to 50%.[4] The sequelae put a significant economic and social burden on the family and healthcare system.

Acid ingestion is commoner in India than in any other country.[4] However, the studies reporting the sequelae of corrosive ingestion in children from India are scarce. Hence, a study was conducted to determine the sequelae of corrosive ingestions in children.

METHODS

A retrospective study was conducted in the Department of Pediatric Surgery at a tertiary center. The children
presenting between January 2015 and December 2020 with a history of ingestion of caustic agents were included in the study. The children who lost to follow-up and the children with incomplete data were excluded from the study. The data were collected from patient charts and telephonic questionnaires. The demographic parameters such as age and gender were recorded. A thorough history was taken regarding the caustic agent ingested, cause for ingestion, and symptoms. Physical examination findings were documented. As most of the children presented to us after 24 h of ingestion, an endoscopic evaluation was avoided. After 3 weeks, the children were evaluated by upper gastrointestinal contrast study followed by an endoscopic examination. However, if the child developed symptoms of obstruction before 3 weeks, a contrast study was carried out with water-soluble contrast.

The management of sequelae was dependent on the symptoms, site of lesion, and type of lesion. Esophageal strictures were treated by dilatation regimen with Savary-Gilliard dilators. The dilatation regimen included “weekly” dilatations thrice, three “biweekly” dilatations, and three “monthly” dilatations. In difficult dilatations, gastrostomy was considered for retrograde dilatation as well as for feeding. Failed esophageal dilatation was defined as the esophageal stricture with persistent symptoms even after the completion of the regimen of esophageal dilatation. Unsuccessful esophageal dilatation was defined as esophageal strictures resistant to esophageal dilatation. The children with unsuccessful or failed esophageal dilatations underwent either resection and anastomosis of the esophageal stricture or the esophageal replacement. Gastric strictures were treated by a modified Billroth I procedure which included resection of stricture and gastroduodenostomy. After the completion of treatment, the children were followed up once 2 weeks for a month, once in 3 months for a year, and yearly thereafter.

Statistical analysis
IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY: IBM Corp., was used to perform the statistical analysis. The continuous parameters were expressed as mean ± standard deviation or median (range) while the descriptive parameters were expressed as number and percentage. The difference between the means was analyzed using the Student’s t-test. The difference between the medians was analyzed using the Mann-Whitney U-test. Chi-square test and Fischer’s exact tests were used to find the difference between the qualitative variables. A $p < 0.05$ was considered statistically significant.

RESULTS
A total of 26 children were included in the study. The mean age of the study group was $8 \pm 4.7$ years. There were 14 boys and 12 girls in the study group. Ten (38%) children were <5 years of age and 10 (38%) children belonged to the adolescent age group. Twenty-one (81%) children ingested acid while the rest (five patients; 19%) ingested alkali. Twenty (77%) children ingested the corrosive agent accidentally, while 6 (23%) were secondary to suicidal attempts. The children with suicidal attempts were significantly older than those who ingested the corrosive agents accidentally [$14.2 \pm 1.9$ years vs. $6 \pm 3.3$ years; $P < 0.01$; Student’s t-test; Table 1]. Time at presentation varied from 1 day to 1½ years after the ingestion with a median of 2 months. The follow-up varied from 3 months to 7 years.

All these children had difficulty in swallowing and painful swallowing as their symptoms. All the children with gastric outlet obstruction presented with vomiting and 60% of them had upper abdominal pain. None of the children with gastric outlet obstruction had visible gastric peristalsis. None of these children had respiratory symptoms. As most of the children presented late, no endoscopy was done in the initial stage of the disease to evaluate the grade of injury. A child who presented with peritonitis 2 days after ingestion of nitric acid was found to have a gastric perforation. She underwent wide resection of perforation, primary repair, and feeding jejunostomy. Postoperatively, she developed intussusception with gangrene of the jejunum requiring resection and anastomosis. The follow-up was uneventful.

All patients underwent contrast study and endoscopic evaluation after 3 weeks of ingestion [Figure 1]. The outcomes of corrosive injury included 16 (62%) esophageal strictures, eight (31%) pyloric strictures, and 1 (4%) combined esophageal and gastric stricture. Twenty (77%) children had superficial oropharyngeal ulcers, managed conservatively. There were no pharyngeal strictures. None of them had laryngeal injuries. Eight (31%) children required an initial feeding jejunostomy and 6 (23%) required a feeding gastrostomy as they had significant weight loss on presentation.

Out of 16 esophageal strictures, esophageal dilatation was not possible in one child with a complete esophageal stricture. Only one child required initial retrograde esophageal dilatation as antegrade dilatation was not possible, the child responded to the dilatation regimen. The rest of the children underwent antegrade esophageal dilatations. A total of 11 (65%) children
with esophageal strictures responded to the dilatation regimen and are symptom-free on follow-up. Two (12%) children with failed dilatation regimen and one child (6%) with complete esophageal stricture underwent esophageal replacement (two gastric tubes and one gastric transposition). Two children are still undergoing dilatation and one child is on gastrostomy awaiting esophageal replacement. Two of the esophageal strictures during the dilatation regimen, presented with foreign body impaction (food) at the stricture site, managed by pushing the foreign body into the stomach.

An 11-year-old female child who had undergone feeding jejunostomy elsewhere for corrosive ingestion 1½ years ago presented with recurrent episodes of cough. The contrast study showed long segment esophageal stricture. Endoscopy was not possible due to tight stricture. She was found to have a tracheoesophageal fistula with a completely strictured esophagus, intraoperatively, which was managed by surgical repair of fistula and gastric transposition. She developed anastomotic stricture which responded to the dilatation regimen. Two other children with esophageal replacement had an uneventful follow-up.

Eight (31%) children had a pyloric stricture and all of them were treated with a modified Billroth I (resection of the stricture with gastroduodenostomy) procedure. A child with combined pyloric stricture and esophageal stricture was managed by a modified Billroth I and esophageal dilatations. The children with a modified Billroth I procedure had an uneventful follow-up.

There was no significant difference between the rate of esophageal strictures and pyloric strictures in the accidental versus the suicidal group and acid versus alkali group [Tables 1 and 2]. The children who presented after 2 months were found to have a significantly increased need for esophageal replacement (3/9 vs. 0/17; \( P = 0.03 \); Fischer’s exact test). None of the patients had significant complications secondary to esophageal dilatation or after surgical interventions.

**Discussion**

An unsafe environment exposes children to various injuries. The developing countries contribute to 95% of child mortality secondary to injuries. The corrosive injury, although declining in developed countries, is still prevalent in developing countries risking the morbidity and mortality of children.\(^2,4\) The data on the presentation and management of children

![Table 1: Accidental versus suicidal ingestion of corrosive agents](image1.png)

| Parameters                        | Accidental (n=20) | Suicidal (n=6) | \( P \) |
|-----------------------------------|------------------|---------------|--------|
| Age, mean±SD (years)             | 6±3.3            | 14.2±1.9      | <0.01* |
| Gender, female, n (%)            | 8 (40)           | 4 (67)        | 0.25*  |
| Time at presentation post-ingestion (median with range) | 2 months (1 month-1.5 years) | 1.5 months (1 day-4 months) | 0.39* |
| Esophageal strictures, n (%)     | 12 (60)          | 4 (67)        | 0.77*  |
| Need for esophageal replacement, n (%) | 3 (15)          | 0             | 0.57   |
| Pyloric strictures               | 6 (30)           | 2 (33)        | 0.79*  |

*Student’s t-test, \(^*\)Chi-square test, \(^\text{aMann–Whitney } U\)-test, ‘Fischer’s exact test

![Figure 1: (a) Esophageal swallow in an upper esophageal stricture (red arrow) showing a thin stream of contrast passing through the lower two-third of the esophagus, (b) Endoscopic view of the esophageal stricture (grey arrow) allowing only a guidewire (red arrow), (c) Contrast meal showing contracted stomach (black arrow), (d) Endoscopic examination showing stasis of food in the stomach (green arrow) with a completely strictured pylorus (white arrow)](image2.png)

![Table 2: Acid versus alkali ingestion](image3.png)

| Parameters                        | Acid (n=21) | Alkali (n=5) | \( P \) |
|-----------------------------------|-------------|--------------|--------|
| Age, mean±SD (years)             | 8±4.5       | 5±4.8        | <0.01* |
| Time at presentation post-ingestion (median with range) | 2 months (1 day-1.5 years) | 1 month (1 month-6 months) | 0.39* |
| Esophageal strictures, n (%)     | 13 (62)     | 3 (60)       | 0.94*  |
| Need for esophageal replacement, n (%) | 3 (14)      | 0            | 1*     |
| Pyloric strictures, n (%)        | 7 (33)      | 1 (20)       | 0.57*  |

*Student’s t-test, \(^*\)Chi-square test, \(^\text{aMann–Whitney } U\)-test, ‘Fischer’s exact test
with corrosive injury in developing countries are underreported. The corrosive ingestion contributed to 0.5% pediatric admissions in Nigeria and 0.3% in the Gambia, with a mortality ranging from 0% to 12% (mean of 4%).

The children contribute 80% of corrosive ingestion worldwide. The age at presentation follows bimodal fashion with children <5 years of age are more commonly affected. Children <5 years are at high risk of accidental ingestion, especially in developing countries, as caustic substances are widely used as household cleaning agents. Contini et al. found that 80% of their study population belonged to <5 years of age. 38% of our study participants were <5 years of age. The second peak of occurrence is seen in the adolescent age group and it occurs due to suicidal attempts. Adolescents contributed 38% of our study population. The mean age at presentation was slightly higher in our study group (8 ± 4.7 years) compared to Turner et al. (2.6 years), Rafee et al. (3.4 ± 1.7 years), Dogan et al. (3.7 years), and Contini et al. (4.5 years).

Our study showed that the boys were a little predominant (1.2:1) than girls which are similar to other pediatric studies such as Turner et al., Rafee et al., Dogan et al., Contini et al., Pintus et al., and Ekpe et al. This finding is unlike adult studies where females are more commonly affected. The adolescent subgroup of our study population also had a female preponderance. This is because females have two times more suicidal ideation than males.

Alkali is the most common (63%) agent ingested by children worldwide. The ingestion of acid is commoner in India compared to other countries. Moreover, 81% of our study group had a history of ingestion of acid. This is due to the easy accessibility of sulfuric acid and hydrochloric acid in India. Our study found no difference in the rate of esophageal strictures between acid and alkali ingestions.

The injuries secondary to suicidal attempts are usually greater and more extensive compared to the accidental injuries as the amount of corrosive agent ingested would be more in suicidal attempts. Moreover, the child may not reveal until it becomes too difficult to tolerate the pain. The suicidal attempts are commonly seen in the adolescent age group. The children in our study who attained injuries following suicidal attempts were significantly older than those with accidental injuries. However, we could not find any difference between the suicidal and accidental groups in terms of long-term effects.

The clinical presentation varies with the amount, type, duration of contact, and physical characteristics of the corrosive agent. The children with epiglottic or laryngeal involvement present with stridor, hoarseness of voice, and/or breathlessness. The children with esophageal involvement will have dysphagia and odynophagia while the children with stomach involvement will have hematemesis and epigastric pain. The hematemesis is usually self-limiting. However, massive bleeding typically occurs 2 weeks following ingestion because of the rupture of blood vessels. Any worsening of the chest or epigastic pain may suggest either esophageal or gastric perforation which can occur anytime within 2 weeks of caustic ingestion. About 10%–30% of children with esophageal caustic injuries have no associated oropharyngeal injury.

The debate on the need for early diagnostic gastroendoscopy is never-ending. A study by Chaudhary et al. proposed upper gastrointestinal endoscopy (UGE) for all the corrosive injuries as they found that the symptoms and signs of corrosive injury do not correlate with the severity of the injury. A multicenter observational study by Betalli et al. found that the symptoms and signs of esophageal and gastric injuries proportionally increase with the severity of the injury. The collagen deposition takes almost 2 weeks after the onset of repair so the tensile strength of healing tissue is very low during the first 3 weeks. Hence, gastroendoscopy is to be avoided between 5 and 15 days to prevent complications. Most of our patients presented late after the injury hence a diagnostic UGE to evaluate the grade of injury was not carried out. However, our entire study group underwent UGE after 3 weeks of injury.

The late outcomes include stricture and malignancy. Strictures can occur in the esophagus, stomach, or small bowel. The children with esophageal strictures present with dysphagia and substernal pressure while the children with antro-pyloric strictures present with postprandial nausea or vomiting and early satiety. The esophageal strictures usually present in 3 weeks or later while the gastric outlet obstruction presents within 6 weeks of ingestion. Esophageal strictures occur due to direct injury by the caustic agent and the effect of gastroesophageal reflux following the injury. Esophageal strictures were seen in up to 50% of corrosive injuries in studies by Contini et al., Ekpe et al., Ake-Assi et al., and Adejuigbe et al.

A study by Mamede et al. reported an esophageal stricture rate of 73%, while the studies by Gundogdu et al. and Christesen et al. reported 73% and 85% rate of esophageal stricture respectively. 65% of our study population presented with an esophageal stricture. The incidence of gastric outlet obstruction in our study...
was 35% which was comparable to other studies such as Mamede et al. (30%).[15] The rate of esophageal malignancy is around 1000–3000 folds following the corrosive injury. Around 3% of esophageal malignancies have a history of corrosive injury. The malignancy manifests about 15 years after the injury and can occur as long as 58 years.[9,15,22] The time at presentation after the caustic ingestion is an important prognostic factor. Our study found that the children who presented after 2 months of ingestion had an increased rate of failure of dilatation of esophageal strictures requiring esophageal replacement. The study by Panieri et al. found that 80% of children who presented after a month of ingestion required esophageal replacement.[22] A study by Contini et al. found that the esophageal dilatations performed late were associated with an increased risk of esophageal perforation and recurrence of stricture.[24] 54% of our study population required an initial feeding gastrostomy or jejunostomy as these children had a significant weight loss on presentation. An initial gastrostomy is indicated to prevent malnutrition or to facilitate retrograde esophageal dilatations.[24] A study by Contini et al. performed gastrostomy in 64% of children with caustic injuries.

69% of our children with esophageal stricture responded to the dilatation regimen. We had no complication of dilatation. Timely dilatation is associated with a better outcome.[9] The risk of perforation in caustic strictures varies from 0.4% to 32% with incidence dropping with increased experience.[9,24-28] A sustained esophageal patency and improvement in the nutritional status of the child both together constitute the reference point of successful dilatations. In failed dilatations and severely scarred esophagus, the choice of replacement includes the stomach, jejunum, and colon. The stomach is more reliable but is associated with reflux, stricture, and columnar metaplasia of the esophageal remnant. These all will lead to functional deterioration over time.[9,28] Colonic substitute is associated with a lower rate of stricture and the functional outcome improves with time. However, the colonic substitution is an extensive surgery, requiring three anastomoses, hence is associated with higher rates of anastomotic leak.[9,25,28] A jejunal substitute may not reach the neck for anastomosis and the blood supply is unreliable. Hence, a free flap of jejunum should be used anastomosing the artery and vein to the carotid and jugular vein respectively.[9,22,25,29] The ideal time of chronic gastric injury repair is debatable. It is better to do a jejunostomy and buy time to allow the stomach stricture to stabilize and to improve the nutrition, which usually takes a few months.[9] Anastomosing the healthy stomach to the duodenum is ideal.[30,31] But in the severe stomach and/or duodenum injury, an antecolic gastrojejunostomy is performed (as the retrocolic gastrojejunostomy interferes with the middle colic arcade making colon mobilization difficult in the future).[9,25] Endoscopic dilatation of gastric stricture has a high failure rate.[3,9,25,30] Pyloroplasty was used in a couple of cases by Dogan et al. with an uneventful outcome.[3] However, gastroduodenostomy is the best option as it restores normal anatomical continuity, removes the unhealthy tissue, reduces dumping, and avoids the possibility of malignancy.[9,25,30] The patients who underwent resection of stricture and gastroduodenostomy in our study had an uneventful follow-up similar to studies by Nagaraj et al. and Ananthakrishnan et al.[30,31] The complications are very rare following gastroduodenostomy as the anastomosis is usually wider and the reliable vascularity of the stomach prevents stricture or leak.

**Conclusion**

The corrosive injury in children is associated with higher morbidity. The sequelae include esophageal and antro-pyloric strictures. A feeding gastrostomy or jejunostomy was required in more than half of the patients. The children presenting after 2 months of ingestion were associated with an increased need for esophageal replacement.

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**Conflicts of interest**

There are no conflicts of interest.

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