

Utilization of Chest Tube in Pediatric Caustic Injuries: A New Method for Esophageal Stenting

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Abstract

Background: The management of caustic esophageal burns in the pediatric population has changed over the years, while the most optimal management with regards to effectiveness, availability, and cost-beneficient stays controvertible. Herein, along with describing the features of caustic injury, we described how to utilize a chest tube for esophageal stenting in pediatrics.

Methods: Data regarding the etiology, treatment, and complications of caustic injury pediatrics during 10 years was collected retrospectively. Furthermore, data regarding the patient's follow-up who underwent esophageal chest tube (ECT) were collected. The ECT was prepared by carving a narrowed section in the chest tube while maintaining the radiopaque section. The ECT will then be positioned from the cricopharyngeal and exited through the nostril and fixed on the patients' cheek.

Results: Data from 57 patients with an average age of 2.5 years was collected. The most common cause of esophageal burn appertained to alkaline agents (89%). Twenty-nine patients (50.8%) recovered with dilatation alone, 16 ones needed esophageal repair, and ECT was inserted for 7 patients. None of the 7 ECT cases required gastrostomy or jejunostomy.

Conclusion: The ECT method introduced in our study can be used as a broadly available, economic, and easy-use facility for esophageal stenting, particularly in developing countries and emergency departments which have limited access to modern equipment. Further multicenter studies with higher volume patients are required for further deployment of this method.

Introduction

Esophageal injury followed by caustic agent ingestion, also known as erosive material ingestion, is among the most challenging and prevalent problems, particularly in developing countries.[1, 2] Complications vary from an asymptomatic effect to drastic outcomes such as esophageal stricture or perforation, which can be potentially fatal.[3, 4] The severity of injury also depends on the type of ingested substance as well as the amount and time of tissue exposure.[5, 6] Esophageal stricture is considered to be the most prevalent complication in these cases.[7, 8]

Children and pediatrics are among the most frequent caustic ingestion victims, which occur either due to accidental and unintentional ingestion of erosive materials.[5] It has also been reported to be more prevalent among males.[9] Furthermore, this problem is most common in toddlers with a prevalence peak of 2 years old.[10, 11]

Acids and alkalis are the two basic types of erosive materials; however, alkaline materials are considered as the most common erosive agents in these cases.[3, 12] Almost 25% of caustic ingestion followed by exposure to personal care products or household chemicals, such as detergent agents and bleaches.[3, 11] The high morbidity and mortality rate followed by these injuries make them a serious challenging issue that requires initial management for all of these patients, including airway assessment, hemodynamic stabilization, and electrolyte replacement, followed by prescribing corticosteroids and antibiotics. [13, 14]

Esophageal stents are considered as an effective method for preventing esophageal stricture in the first 48 hours and also eliminating esophageal stricture recurrence followed by other dilation methods; however, the effectiveness, accessibility, and problems that these stents cause for the patients are still a challenging issue.

Therefore, in this study, we aimed to introduce a new esophageal stenting method by utilizing a chest tube as an available and accessible device in emergency departments in patients suffering from caustic injuries. We also reviewed the etiology of caustic injury pediatrics in southern west Iran and the outcome of several patients treated with this Technique.

Materials And Methods

Study design and setting

In this retrospective study, hospital records during ten years (1394–2004) of patients admitted due to caustic chemical ingestion at Shiraz Namazi Hospital, which is a referral center for pediatric injuries in southern Iran, were collected. Data regarding the patient's characteristics, age, cause of the burn, degree of burn, treatment with antibiotics and steroids, use of gastrostomy and jejunostomy, number of dilatations and intervals, surgeries performed, and their complications (anastomotic leakage, esophageal rupture, adhesions, other early and late complications which were in associated to burns) was also gathered.

Esophageal Chest Tube Stenting Method

In this method, the Esophageal Chest Tube (ECT) stent is inserted either in the first 48–72 hours after a caustic injury or precisely after dilatation and is removed after 6–8 weeks. In this technique, we utilize the ECT in three steps.

First, the chest tube's length is measured concerning age, weight, and the stature of each patient. A narrowed section is shaped by obliquely carving the chest tube and maintaining the radiopaque section (Fig. 1A and Fig. 2), which will be positioned from the cricopharyngeal until the external section of the tube. After preparing the ECT, the tube will be inserted orally via endoscopy through a guide wire, with the narrow end positioned out of the mouth (Fig. 1B). Following the ECT insertion, we aim to exit it through the nasal cannula, in which we use either a Nelaton or nasogastric (NG) tube. In this regard, we insert the tube through the nasal cannula so that it exits the mouth while keeping the proximal section out of the nose. Subsequently, the end part of the tube is sutured to the distant narrow part of the ECT (Fig. 1C). Therefore, by pulling onto the proximal part of the tube, it will act as a guide for the ECT to extract it through the nasal cannula (Fig. 1D). Consequently, the ECT will exit the nose and fixed to the patients' cheek using tape. (Fig. 2). Also, by preserving the radiopaque section of the ECT, monitoring the position of the tube is possible through chest radiography. (Fig. 3)

Follow-up Evaluation

Then patients were evaluated for early complications such as pneumonia, pneumothorax, esophageal rupture, etc. or late complications such as esophageal stricture, gastroesophageal reflux, and the need for colon interposition.

Results

During the period of our study, data from 57 patients with an average age of 2.5 years (range 1–12; SD = 1.7) were obtained. The results showed that 89% of esophageal injury was due to alkaline and 9.4% caused by acidic agents. Table 1 demonstrates the etiology factors of the patients in our study.

Table 1
Etiological features of caustic injury among pediatrics in southern west Iran

Variable	Frequency <i>n</i> = 57	Percentage (%)
Etiology		
Caustic Soda	47	83.3
Stove-top cleaner	3	5.7
Acid	3	5.7
Hydrochloric acid	2	3.7
Boiled water	2	3.7
Degree of injury		
Second degree	44	79.6
Third Degree	11	20.4
Medical treatment		
Antibiotic Therapy	36	66.7
Corticosteroids	22	40.7
Advanced treatment		
Dilatation	29	50.8
Stent insertion	7	12
Colon interposition	16	28
Other surgical methods	5	8.7
Surgical treatment		
gastrostomy	19	33.3
jejunostomy	4	7.4
Complication		
No complication	39	69.6
pneumothorax	11	19
Esophageal rupture	6	11.4

The treatment methods showed that 29 patients (50.8%) recovered with dilatation alone. In 16 patients (28.06%), the esophageal repair was performed by using the colon, and in 5 patients (8.7%), other surgical methods were used and in 7 patients (12.2%), the ECT stents were used.

ECT was inserted in 7 cases with a mean age of 2 (range: 1.5-3) years. Grading was performed by endoscopy assessment during the first day. Antibiotics and corticosteroids were administrated as initial medical management for all patients. ECT implantation was done during the first 8 days for 5 out of 7 cases (mean: 3.8 days). For the 2

patients, ECT was used after 27 (patient 6) days 83 (patient 7) days. The reason for late stenting in these patients was a postponed referral to our center, in which patient 7 even received 4 dilation episodes before visiting our center. ECT was removed after an average of 44 days in the first 5 patients, while in the other 2 patients (6 and 7) was 2 and 1 week, respectively.

It is worth mentioning that none of the 7 ECT cases required gastrostomy or jejunostomy.

Table 2
Caustic injury pediatrics treated with esophageal stenting using a chest tube.

Variable	Patient						
	1	2	3	4	5	6	7
Age (months)	24	24	18	36	24	30	34
Grade	III	II	II	II	III	II	I
Etiology	Caustic Soda	Hydrochloric acid	Acid	Acid	Caustic Soda	Stove Cleaner	Caustic Soda
Time of ECT insertion (days after injury)	1	6	8	2	1	27	83
ECT Duration (Days)	27	35	50	90	20	16	7
Number of Dilatations After ECT	0	1	1	4	12	9	2
Dilation Intervals	0	0	0	0	0	0	4
Replacement (Frequency: Days)	1:14	-	2:12 and 22	2: 30 and 60	-	1: 9	1: 4
Surgical Intervention	-	-	-	-	Colon Interposition	-	-
Duration of follow-up (month)	23	22	16	6	35	15	14
Patient Satisfaction	Satisfied	Satisfied	Satisfied	Mild Esophageal Stenosis	Satisfied	Satisfied	Mild Esophageal Stenosis

Discussion

Caustic injuries are considered as one of the most prevalent, as well as preventable accidental injuries. Children are among the highest groups at risk of these injuries due to their curiosity and ability to reach objects without discerning their harm and potential dangers. In 2009, the Kids' Inpatient Database of the United States reported 807 cases of caustic injuries. Our study was conducted in southwest Iran, in which 57 pediatrics hospitalized patients

with caustic injuries were collected during 10 years (1994–2003), demonstrating an annual rate of 5.7 cases/year. In similar studies in our province, Honar et al.[15] reported 75 in 2006–2011 (12.5 case/year) and Dehghani et al.[9] reported 41 cases from 2015–2016 (20.5 cases/year). This upsurge in the number of cases shows the significance of this matter and therefore, evaluating the etiology and applied managements, along with choosing the proper therapeutic option in these patients is necessary.

Among the contributing factors to this increasing number of cases per year may be the increased use, easy accessibility, and low cost of detergents and bleaches, especially in developing countries. Alkaline was considered as the most corrosive agent in this study with an incidence of 89% (50 out of 57 cases), while acid agents consisted of 9.4% (5 out of 57 cases) of the etiologies in our study population. In a similar study in our center, 64 hospitalized patients were reported to have alkaline ingestion during a 4 year period. [10] Also, in a study conducted in Australia, 74% of caustic ingestion occurred by alkaline agents.[16] Acids, regarding their low viscosity and therefore rapid transfer to the stomach and also due to their nature cause coagulation necrosis, with eschar formation that may prevent further damage and limit the injury depth. Conversely, alkalis bind to tissue proteins and lead to liquefactive necrosis and saponification, and penetrate deeper into tissues, assisted by a higher viscosity and a longer contact time through the esophagus. On the other hand, children usually tend to swallow a larger amount of alkaline because alkalis are usually odorless and tasteless; although, acidic agents have a sour taste which makes children spit them out. Another point for our region (the south of Iran) is the excessive use of air conditioner following by its cleaner that fundamentally and are made by NaOH which kept in beverage bottle without any warning label in addition to the low educational level of parents have led to increasing the occurrence of esophageal burn by caustic ingestion.

In caustic injury patients, a preliminary survey includes airway assessment as well as fluid and electrolyte balance. [11] We also administered antibiotics along with corticosteroid as medical management. Among the most imperative complications of esophageal burns is stricture. Katz et al.[8] reported esophageal stricture in more than 90% of patients with grade 3 and almost 30–70% of grade 2B caustic injury. Malignant transformation to esophageal cancer is one of the following complications of esophageal stricture.[17] Studies have also reported that esophageal stricture is associated with hiatal hernia, reflux disease, dysphagia symptoms, and causing difficulties for esophageal reconstruction. [18–20] A study in 1992 evaluated the administration efficacy of antibiotic and systemic steroids simultaneously in caustic ingestion, which concluded that antibiotics with steroids might be useful in reducing strictures in patients with esophageal burns.[21] Controversially, a controlled randomized trial revealed the corticosteroids' ineffectiveness in preventing esophageal stricture in children with a caustic injury.[22] Therefore, novel therapeutic approaches for preventing or managing esophageal strictures that would enable a child to tolerate an oral diet in a more expeditious and less invasive manner would be highly desirable. Furthermore, the oblique cutting of the ECT facilitates feeding and also prevents unintentional aspiration.

In this report, we utilized the chest tube, as a broadly available and well-known equipment in all emergency departments, proposed as an esophageal stent for not only preventing esophageal stricture in the first 48 hours but also after dilatation. Formerly, self-expanding plastic stents (SEPS) and fully covered self-expanding metal stents (FCSEMS) have been used for stenting, and each had its advantage and disadvantage. The success rate for SEPS showed 50% by Broto et al.[23] and 75% for FCSEMS by Zhang et al.[24]

Stent migration is another common complication that has been reported from 14–48% of cases, which has been related to the type of stent [25]. Metal stents which are fully-covered with polytetrafluoroethylene (PTFE), polyurethane, or silicone have a higher chance of migration, compared with uncovered metal stents, which are held

in place by hyper-granulation and mucosal ingrowth [26, 27]; nevertheless, these proliferations contribute to ulcers and struggle when removing the stent. Self-expanding plastic stents are at greater risk of migration when compared with self-expanding metal stents, which are daunting in benign esophageal stenosis due to its high incidence of necrosis and ulceration, tissue hyperplasia, new stricture or fistula formation, and the tendency for the metal portion to embed within the esophageal wall [28, 29]. Best et al. (2009) and Manfredi et al. (2014) reported high rates of mucosal ingrowth and hyper-granulation, causing difficulty in stent removal and stent-induced ulceration.[29, 30]. Since the ECT is inserted from below the cricopharyngeal till the lower esophagus sphincter and also fixed from outside of the nose, this decreases the chance of migration compared to other methods of fixation using thread and suture. Furthermore, the stent material safeguards cell proliferation into the stent, resulting in easy removal of the ECT and less complication such as esophageal ulcer and hyper-granulation.

From an economic point of view, as one of the most important factors in management decision making particularly in developing countries, the proposed ECT can be an ideal choice due to its cost-effective aspects and in centers where other esophageal stents are unavailable.

Among the other advantages of the ECT is that the patient will be able to tolerate oral feeding with soft diets as well as liquids, so the foods are based on the inlet of the ECT, which is located in the cricopharyngeus area and allows a pathway to the stomach. However, since the ECT covers the total length of the esophagus to the lower sphincter, a risk of reflux should be considered which can be managed with proper anti-reflux medication.

Among the patients in our study, 5 were satisfied with their results, while two (patients 4 and 7) had mild esophageal stenosis. Among these two, patient 4 had ECT for 90 days. The exact duration in which stents should be used is still a matter of debate. The European Society for Gastrointestinal Endoscopy Recommendations for the Stenting of Benign Esophageal Strictures acknowledges this lack of data available and suggests the insertion of self-expanding metal and plastic stents for a minimum of 6–8 weeks and no more than three months.[31] Likewise, we recommend removing the ECT after 6–8 weeks. Furthermore, patient 7 had ECT inserted after 83 days after the injury, which had already caused chronic damage and stricture. It is also worth mentioning that ECT was inserted in one of the patients with grade I of caustic injury, which was intended as prophylaxis for esophageal stenosis.

Endoscopic dilatation with balloon has been the standard of treatment for benign esophageal strictures; nevertheless, the recurrence rate was reported to be 30%-40%. [28] Increasing the victims of caustic ingestion on one hand, and the high economic burden, on the other hand, made us use the ECT in early stenting, which is more economical, broadly available, and also regarding its high efficacy.

Several caveats regarding our study deserve mention. First, this was a retrospective, single-institution series of esophageal stents deployed in a heterogeneous group of patients. Also, our series lack of control group and consists of a small sample size. This study was non-comparative and did not compare stenting to other therapeutic options. However, our study's main focus was utilizing an already existing device, the chest tube, as an esophageal stent for the early management of caustic injury pediatrics, especially in centers with limited equipment.

Conclusion

Caustic injury and its management are amongst the most challenging problems among pediatric surgeons. The availability, efficiency, and economic aspect of material are important factors that should be taken into consideration in planning the therapeutic approach of these patients. In this study, we successfully report utilizing a chest tube, as an available device in almost every emergency department, as a method for esophageal stenting.

This method should especially be considered in developing countries with limited utilities and also emergency departments and centers with restricted access to modern equipment.

Declarations

Authors' contributions

HF, HH designed the study and obtained ethical approval, SE collected the clinical data and FP carried out the data gathering. RS and MS drafted the manuscript while HH and HF edited and prepared the final version of the article. All author proofread and approved the final version of the manuscript.

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Availability of data and materials

All data regarding this study has been mentioned in the manuscript. Please contact the corresponding author in case of requiring any further information.

Ethics approval and consent to participate

Written informed consent was obtained from the patients' parent/guardian in our study. The purpose of this research was completely explained to the patient's parents/guardian and was assured that their information will be kept confidential by the researcher. The present study was approved by the Medical Ethics Committee of Shiraz University of Medical Sciences.

Consent for publication

Consent was obtained from the patient parent/guardian regarding the publication of this case report.

Competing interests

The authors declare that they have no competing interests.

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None to declare.

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Figures

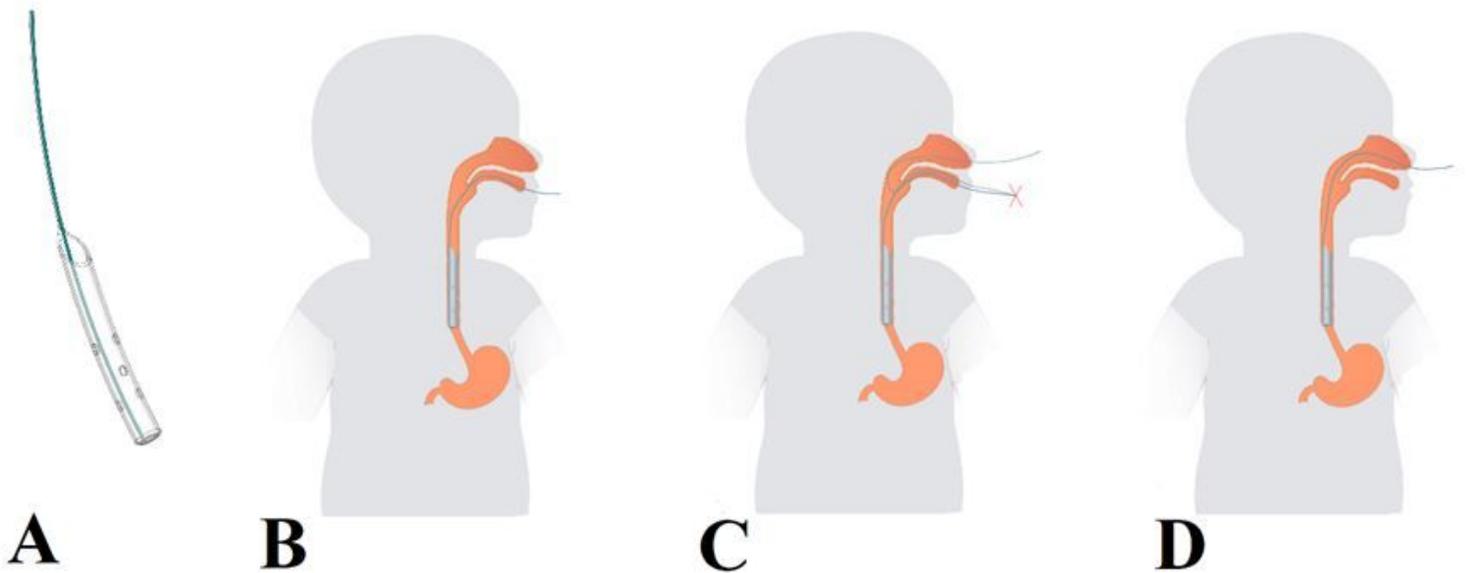


Figure 1

Utilizing a chest tube as an esophageal stent in caustic injury in pediatrics; (A) prepared esophageal chest tube (ECT) (B) insertion of ECT from cricopharyngeal until lower sphincter and exiting the external part from the mouth (C) suturing the external part of the ECT to a Nelaton or nasogastric (NG) tube which has been passed through the nostrils (D) exiting the external part of the ECT through the nostrils.

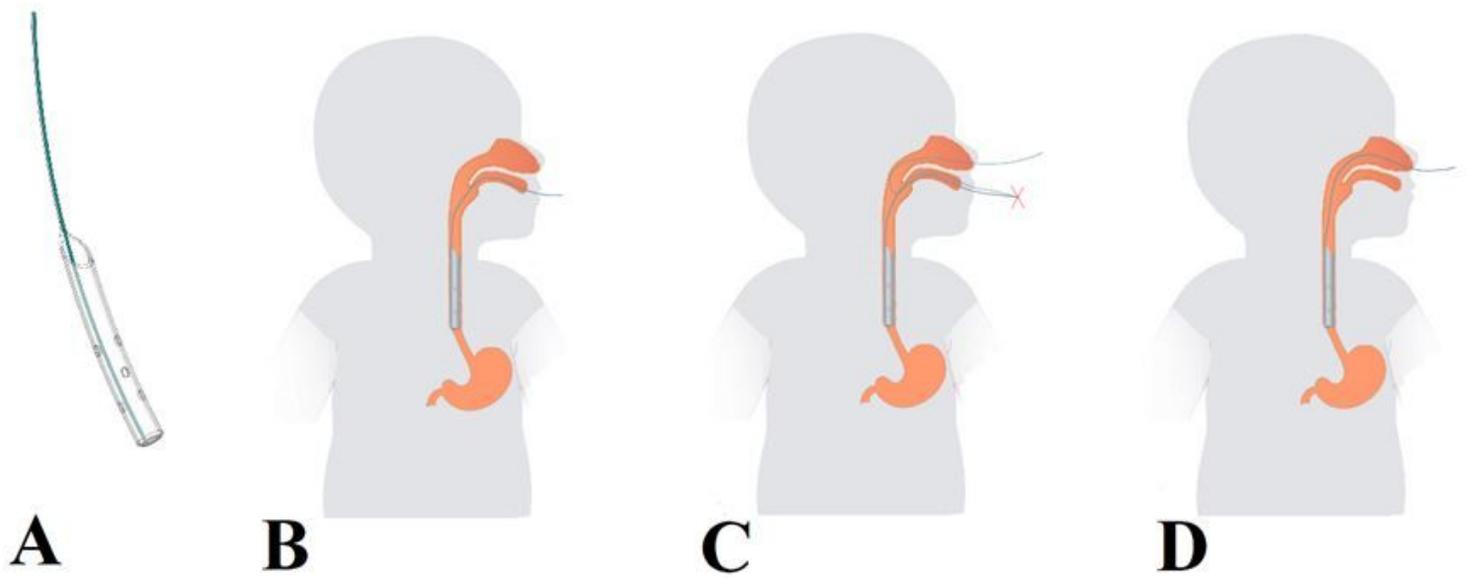


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Figure 2

Esophageal chest tube (ECT) prepared (A) and fixed (B) for a 6-year-old boy with a caustic injury



Figure 2

Esophageal chest tube (ECT) prepared (A) and fixed (B) for a 6-year-old boy with a caustic injury



Figure 3

Chest radiography demonstrating and esophageal chest tube (ECT) inserted for a patient with a caustic injury



Figure 3

Chest radiography demonstrating and esophageal chest tube (ECT) inserted for a patient with a caustic injury