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INVITED REVIEW

# Early management of acute caustic ingestion in pediatrics

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**Abstract**

This review is intended to provide an overview of currently available literature related to caustic ingestion in pediatric patients, including initial management considerations in symptomatic versus asymptomatic children, timing and necessity of endoscopic evaluations, and the use of various therapeutic interventions. Further, this review provides management considerations for children presenting for evaluation following caustic ingestion based on the best available evidence. Additional research is needed to develop conclusive pediatric guidelines that meet GRADE criteria for management of caustic ingestion in children.

**KEYWORDS**

children, endoscopy, pediatric gastroenterology

## 1 | INTRODUCTION

### 1.1 | What is "caustic ingestion"?

Caustic ingestion in the pediatric population is a significant global health concern.[1] Caustic exposure among children typically occurs accidentally, even in the presence of parental supervision. Ingestions may cause severe esophageal, gastric, and intestinal mucosal damage, potentially leading to esophageal fibrosis and stricture formation, which may result in esophageal stasis, loss of normal esophageal peristalsis, delayed gastric emptying, and abnormal gastric motility.[2] Risk factors for exposure include improper storage of household caustics, male sex, age less than 6 years, and maternal literacy.[3]

"Caustic substances" include either strong acids or strong bases (see Table 1). The extent and characteristics of tissue destruction depend on the properties of the ingested substance. Strong bases (alkalis) have a pH greater than 12.[4] Alkaline substances, implicated in the majority of pediatric caustic injuries, are highly viscous, and remain in contact with esophageal mucosa for extended periods leading to deep tissue penetration, causing liquefactive necrosis via saponification and break down of cell membranes.[5] This results in thrombosis of vessels and fibrosis of tissue, which can lead to perforation.[6,7] Alkalis often injure the proximal intestinal tract (e.g., mouth, pharynx, esophagus, and stomach) and trachea (if aspirated). Alkalis with a pH less than 12 rarely cause significant injury unless large quantities are ingested. In contrast, significant injury has been noted with ingestion of substances with pH greater than 12.[1]

Conversely, strong acids with a pH less than 3 may, upon ingestion, result in coagulative necrosis leading to ischemia without deep penetration or perforation.[1]

Owing to their bitter taste, strong acids are associated with smaller-volume ingestions. Given their lower viscosity and rapid esophageal clearance, they are less likely to cause esophageal injury. However, their faster clearance often causes increased gastric antral injury or body erosions and inflammation, leading to bleeding. Important considerations include the health of the tissue before injury (children typically have normal and healthy mucosa) and the duration of time that the corrosive agent is in contact with the mucosa.

As ingestion in young children is most commonly accidental, the volume of the offending agent is typically minimal, resulting in low mortality as opposed to intentional

**TABLE 1** pH of common household substances.

| pH | Substance |
|---|---|
| 0 | Hydrochloric acid |
| 1 | Battery acid (sulfuric acid)<br>High-acid toilet bowl cleaner<br>Stomach acid<br>Drain cleaner |
| 2 | Coca-Cola©<br>Vitamin C-based (ascorbic acid) Skincare Products (pH 2.6–3.2) |
| 3 | AHA and BHA exfoliant products (pH 3 and 4)<br>Apples<br>Ceramic tile cleaner<br>Fruit juice<br>Lemon juice<br>Low-acid toilet bowl cleaner |
| 4 | Beer<br>Carbonated water<br>Skincare cleansers (pH 4–7)<br>Vinegar<br>Wine |
| 5 | Black coffee<br>Skin moisturizers (pH 5–7)<br>Skin toners (makeup, pH 5–7)<br>Sunscreen (pH 5–7) |
| 6 | |
| 7 | Blood (pH 7.4)<br>Dish detergent (pH 7 and 8)<br>Milk<br>Pure water |
| 8 | Baking soda<br>Distilled water<br>Egg |
| 9 | Deodorants<br>Dry floor finish products<br>Hand soap<br>Neutral cleaners |
| 10 | Borax<br>Degreaser (Stinger©)<br>Glass cleaners (Windex©)<br>Hair shampoo<br>Laundry detergent<br>Milk of Magnesia (pH 10.5) |
| 11 | Ammonia<br>Nonacidic toilet bowl cleaners<br>Pine cleaners<br>Tube and tile cleaner (pH 11–13) |
| 12 | Degreasing agents<br>Household disinfectant cleaners (Lysol©, Clorox©)<br>Lime (calcium hydroxide)<br>Oven cleaner (pH 11–13) |
| 13 | Bleach (industrial, pH 11–13)<br>Floor finisher<br>Mildew stain removers |
| 14 | Crystal drain cleaner (Drano©)<br>Liquid crystal drainer (e.g., liquid plumber)<br>Sodium hydroxide (“lye,” hair relaxers) |

Abbreviations: AHA, alpha hydroxy acid; BHA, beta hydroxy acid.

### What is Known

- These findings can guide the development of targeted genetic tests in Jordan, enabling faster and more accurate diagnosis.
- The extent of tissue damage depends on the properties of the ingested substance, with alkaline substances (pH >12) causing more severe esophageal injury due to their viscosity and prolonged tissue contact, while acids typically cause less esophageal but more gastric injury.
- The Zargar classification system (grades 0-3b) remains the standard for evaluating caustic injury severity during endoscopy, with grades 2b and above often associated with long-term complications requiring intervention.

### What is New

- In asymptomatic patients, a thorough evaluation including risk factors, physical exam, and discussion with poison control may guide the need for endoscopic evaluation though a minimum 6-hour observation period (24 hours optimal) is recommended for monitoring.
- In symptomatic patients, EGD within 24-hours is most optimal to evaluate the degree of injury and for prognostication.
- CT imaging is not recommended as a replacement for endoscopic evaluation in children, and recent evidence shows limited utility of systemic steroids in preventing stricture formation in the acute post-ingestion period.
- Further research is needed on the use of steroids, antibiotics, and acid-suppression while early placement of NGT under direct visualization during endoscopy may help prevent stricture formation and allow for enteral nutrition in cases of significant injury (Zargar grade 2b and above).
- Multicenter registries are needed to capture population-level data, which will aid in the development of evidence-based clinical guidelines meeting GRADE criteria.

ingestions which occur more frequently in adolescents and adults and involve larger volumes.[8,9] Data regarding the extent of injury in accidental versus intentional ingestion have been evaluated retrospectively in pediatric patients.[10] The authors noted that there was a statistically significant difference between the degree of mucosal injury to the esophagus among patients who attempt suicide by caustic ingestion as compared to those with accidental ingestion ($p = 0.002$).[10]

## 1.2 | Epidemiology

In 2020, the American Association of Poison Control Centers reported 3.3 million completed telephone encounters related to exposures to toxic substances of any type, a 30% increase in overall calls since 2019. Over 2.1 million calls were for toxic human (vs. animal) exposures, with approximately half of toxic exposures occurring in young children 5 years of age and under.[11] More than 15.8 cases per 100,000 children in the United States are reported annually, with 80% of these exposures involving caustic substances. Given their wealth of knowledge and expertise, and the unique exposure to caustic ingestion cases, poison control centers are a vital first consult when a patient presents for evaluation following caustic ingestion.

The top five most common exposures in children were cosmetics/personal care products (12% of calls), household cleaning substances (11%), analgesic medications (7.57%), foreign bodies/toys/miscellaneous (6.71%), and herbals supplements (6.44%).[11] About 30%–40% of calls were related to potentially dangerous ingestions which have the potential to cause significant injury.[12]

## 1.3 | Zargar scoring

A seminal, prospective study by Ali Zargar (1991) [13] more objectively quantified the extent of injury following caustic ingestion and formed the basis for what is now known as "Zargar scoring." Zargar assessed and characterized the utility and visual findings of esophagogastroduodenoscopy (EGD) following caustic ingestion in the management of 81 patients. Of the 381 endoscopies performed, 88 occurred within 96 h after ingestion, while 108 were performed between 3 and 9 weeks following ingestion. An additional 185 endoscopies occurred as follow-up of bougie dilation of esophageal strictures. Upper gastrointestinal burns were graded from 0 to 3, with Grades 2 and 3 further subdivided into 2a, 2b, 3a, and 3b. Those with Grades 0, 1, and 2a burns recovered without long-term implications. Grades 2b and 3 injuries were associated with long-term complications, including esophageal and/or gastric scarring necessitating endoscopic or surgical treatment, while early complications and deaths occurred in patients with Grade 3 burns (see Table 2). Given the long-term implications of significant injury, it is prudent to evaluate patients endoscopically. However, the timing for endoscopic evaluation has been, and continues to be, the topic of much debate.

## 1.4 | Methodology

Caustic ingestions often require collaboration and coordinated action by multidisciplinary teams, including gastroenterology (GI), surgery, and otorhinolaryngology (ENT). As such, to comprehensively evaluate the literature pertaining to pediatric caustic ingestions, it is imperative to understand appropriate management considerations from the perspective of the teams involved.

Cochrane Review, PubMed, and National Library of Medicine literature searches yielded 1391 articles related to caustic ingestion published from 1947 through 2023, further refined to 472 possible results after conducting searches by subspecialty (Table 3). All abstracts were initially reviewed for utility based on inclusion and exclusion criteria (Table 4).

For the purposes of this review, we evaluated the available data from 93 studies based on symptomatic versus asymptomatic pediatric presentations in the context of the evaluation by various subspecialists involved in patient care.

## 1.5 | Initial evaluation considerations in symptomatic patients

Typically, the first step in assessing the extent of injury in a patient following caustic ingestion is ensuring a stable airway, followed by oropharyngeal evaluation. In those patients who are symptomatic on presentation, particularly if Emergency Medical Technician evaluation and report are suggestive of an initially unstable airway, then an airway evaluation by ENT is suggested. Urgent airway assessment and securing a definitive airway in those with airway compromise is a vital first step in the management of children presenting following caustic ingestion.[15] In suspected perforation, a surgical opinion should be sought immediately. Where symptomatic patients are found to have a stable airway and lack clinical signs and/or symptoms of perforation (significant abdominal or chest pain, sudden onset of breathing difficulty; tense abdominal distension; hemodynamic instability, radiographic studies notable for free air under the diaphragm or mediastinum), based on the best available literature, endoscopic visualization of the esophageal mucosa with an EGD, appears to be most optimal when performed within 24 h to evaluate the degree of injury and for prognostication.[12,16,17] Prospective studies are needed to further specify optimal timing for evaluation of the esophageal mucosa.

Based on the best available evidence, management considerations in symptomatic patients may include:

1. Any patient with airway/respiratory symptoms may be admitted to the pediatric intensive care unit (PICU).
2. Any patient following assessment of the ingested substance, if pH > 12 and volume is potentially substantial, PICU admission should be considered.
3. Any patient requiring ENT evaluation, whether airway injury is detected on direct laryngoscopy and bronchoscopy or not, PICU admission should be considered.

**TABLE 2** Search terms and results.

| Pediatric ENT | Pediatric + otolaryngology + caustic + ingestion |
|---|---|
| 14 | Crystal drain cleaner (Drano©)<br>Liquid crystal drainer (e.g., liquid plumber)<br>Sodium hydroxide ("lye," hair relaxers) |

| Specialty | Terms searched | Number of results |
|---|---|---|
| Pediatric otolaryngology | Pediatric + otolaryngology + caustic + ingestion | 49 |
| Pediatric gastroenterology | Pediatric + gastroenterology + caustic + ingestion | 213 |
| Pediatric surgery | Pediatric + surgery + caustic + ingestion | 391 |

Abbreviation: ENT, otorhinolaryngology.

**TABLE 3** Inclusion and exclusion criteria.

| | |
|---|---|
| Inclusion criteria | 1. English language<br>2. Studies included patients ages 0–18 years<br>3. Involved acute ingestion of caustic substances |
| Exclusion criteria | 1. Published in foreign language without available English translation<br>2. Chronic outcomes of caustic ingestion without discussion about acute presentations or management<br>3. Did not review the same study two times (i.e., if search results yielded the same study two times, it was reviewed once)<br>4. Single study case reports |

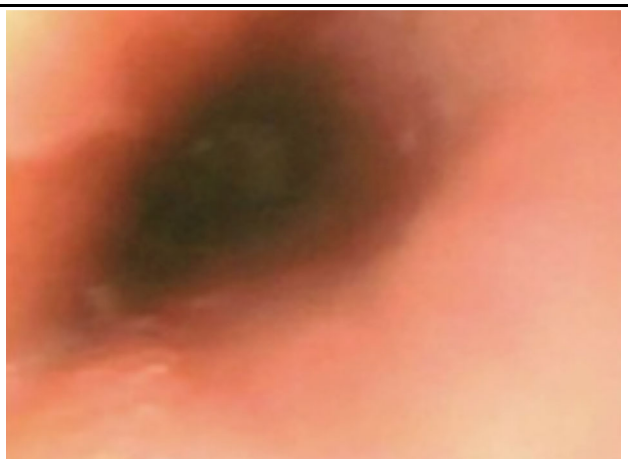
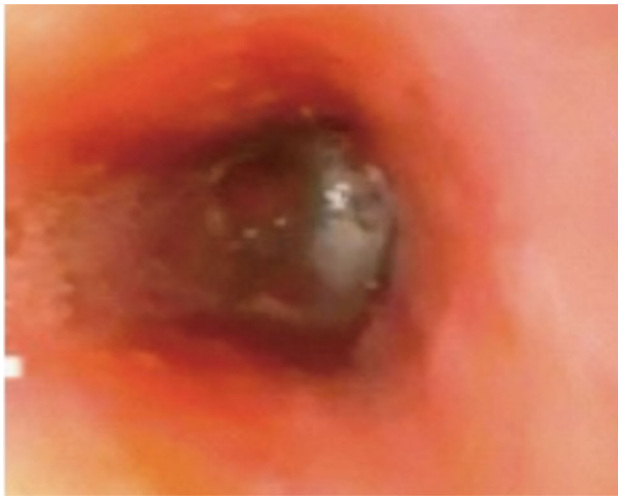
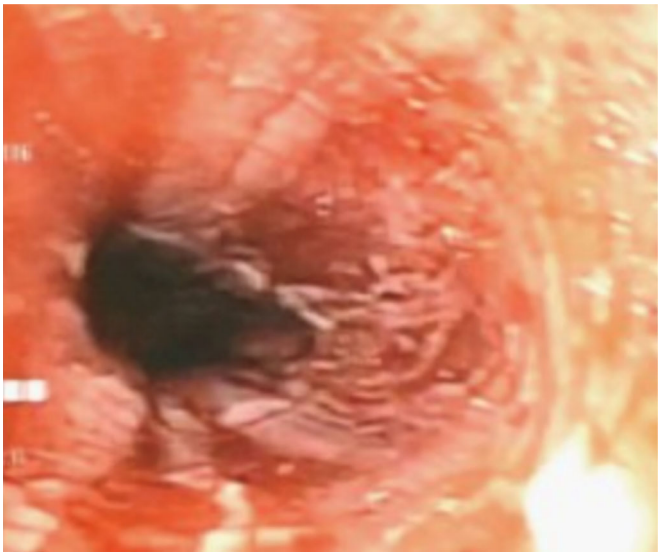
## 1.6 | Evaluation of asymptomatic patients

Several researchers have tried to answer the question regarding the evaluation and management of pediatric patients who are asymptomatic following caustic ingestion.

Gupta et al.[18] found that all patients with clinically significant injury (Grades 2 and 3) were symptomatic at initial assessment, but no single symptom or combination of symptoms could identify all patients with esophageal injury. In the Gupta study, the majority of patients ($N = 28$) had normal findings on EGD, with 14% (4 out of 28) of patients both asymptomatic and with normal endoscopic findings and another 57% (16 out of 28) who were symptomatic but with normal findings (approximately 71% with normal endoscopic findings irrespective of symptomatic presentation). The group concluded that EGD appears "unnecessary in asymptomatic patients with alleged caustic ingestion" but suggested that "a larger, prospective study would be necessary to unequivocally answer this question."[18] Based on our review of the literature and the best available evidence, as well as our collective experience—future studies that characterize the natural history of caustic ingestion in a large population of children could be relatively easily done, and important information gained to help with the prognostication, as well as appropriate, evidence-based guidance for initial and long-term management of these children.

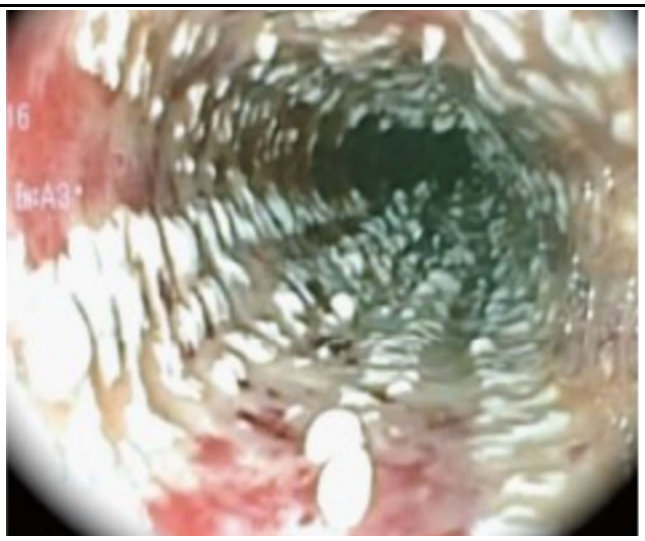
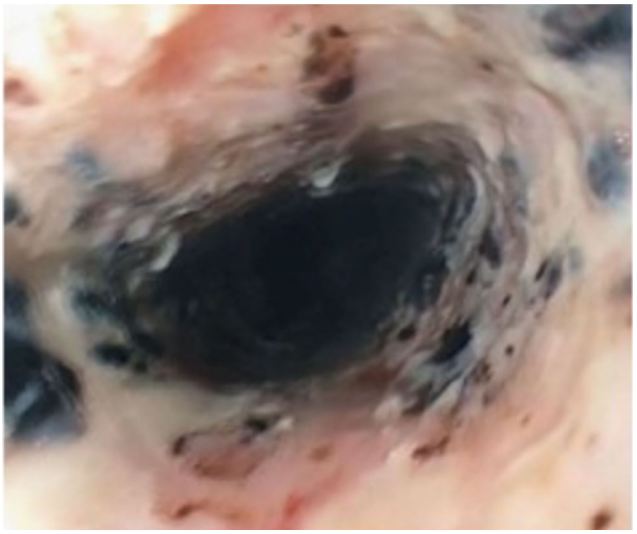
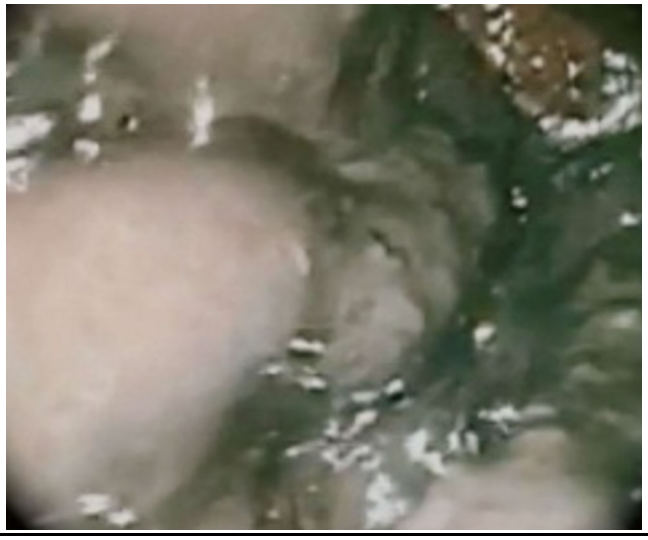
A multicenter study completed by the Caustic Ingestion Italian Study Group evaluated the indication for EGD in 162 cases of suspected caustic ingestion.[19] The risk of severe esophageal lesions without signs and/or symptoms was very low. Indeed, the presence of three or more symptoms was an important predictor of severe esophageal lesions (odds ratio [OR] = 11.97 [95% CI = 3.49–42.04], $p = 0.0001$), which is similar to findings of other studies. Multivariate analysis in this Italian study showed that the presence of symptoms is the most significant predictor of severe esophageal lesions (OR = 2.3 [95% CI = 1.57–3.38], $p = 0.001$). The likelihood of an asymptomatic patient presenting with severe burns is very low; thus, the authors propose that EGD may be avoided in asymptomatic patients. The risk of severe damage increases proportionally with the number of signs and symptoms, and they suggest that EGD be considered mandatory in symptomatic patients. Similar findings have been discussed in other studies, notably when oropharyngeal injuries are the only signs of initial evaluation, gastric injuries are unlikely and EGD may be avoided, particularly where ingestion is suspected but not confirmed.[20,21] One must recall that, despite their overall well appearance, asymptomatic patients and/or those with respiratory symptoms, may have significant findings on EGD, including edema, erythema, or ulceration, and children may not appropriately or adequately verbalize the presence or absence of symptoms, which may change

**TABLE 4** Zargar scoring with endoscopic results.

| Grade | Degree of injury | Risk of stricture development | Endoscopic images |
|---|---|---|---|
| 0 | Normal mucosa | Limited |  |
| 1 | Mucosal erythema and edema | Limited |  |
| 2a | Superficial ulceration, erosions, possible hemorrhage | Limited |  |

(Continues)

**TABLE 4** (Continued)

| Grade | Degree of injury | Risk of stricture development | Endoscopic images |
|---|---|---|---|
| 2b | Circumferential ulceration | May occur in up to 70% of patients |  |
| 3a | Localized brown-to-black ulceration or deep gray lesions | May occur in >90% of patients |  |
| 3b | Extensive brown-to-black ulceration or deep gray lesions | May occur in >90% of patients |  |

*Note*: Image credit.[16]

short-term management strategies.[22] The evaluation for oropharyngeal injuries with a complete and thorough oropharyngeal exam may be conducted by the initial evaluating ER clinician or, if available, ENT. Thus, we propose EGD be considered on an as-needed basis and as clinically appropriate in asymptomatic patients, especially given the type and volume of substance ingested, if that information is available from the caretaker(s).

While asymptomatic adults may not require an EGD, asymptomatic pediatric patients with suspected but unconfirmed ingestion should be approached cautiously with a period of close observation. Consideration should be given to a minimum period of 6 h of observation (24 h optimal) with cardio-respiratory and pulse oximetry monitoring, with site of monitoring (i.e., emergency room and inpatient observation) at the discretion of the supervising physician.

## 1.7 | Timing of endoscopic evaluation when deemed necessary

Multiple studies show that delaying EGD up to 24 h after ingestion allows for assessment of the full extent of injury.[23–29] While it is understood that early EGD is considered safe 24 h after ingestion, one must be mindful of contraindications to endoscopic evaluation including suspected perforation and epiglottitis. With higher-grade injury, risks of bleeding and perforation increase with intervention.[30] Performing EGD too early can be detrimental to patient outcomes as it may take up to 24 h for the evolution of injuries from caustic exposures and thus these findings may be missed if the EGD is performed too early.

Significantly delaying evaluation beyond 24–48 h may not be ideal. While Zargar reported that EGD up to 96 h following ingestion is safe, injured esophageal mucosa becomes more fragile and prone to perforation due to ulceration and the laying of granulation tissue 48 h after ingestion. Granulation tissue is necessary for healing at the site of damage.[13,31,32] Delayed EGD may increase the risk of perforation especially given that the "burned esophagus is weakest between the 7th and 21st day of injury," which would render endoscopic evaluation during this period ill-advised.[30,33]

## 1.8 | Predictive value of presenting signs and symptoms and necessity for endoscopic evaluation

Several studies have sought to evaluate the predictive validity of presenting signs and symptoms following caustic ingestion for the purposes of estimating the likelihood of positive findings on EGD. Odynophagia, drooling, and food refusal are suggestive of more severe injury (greater than Grade 1).[31] The predictive value of visible lesions in suspected caustic ingestion has been evaluated in the context of the necessity for endoscopic evaluation in pediatric patients with complete absence of oropharyngeal findings.[34] The relationship between the absence or presence of grossly visible lesions on the cheeks, lips, and oropharynx and the incidence, site, and degree of visceral burns in all children referred for a suspected caustic ingestion was evaluated during a 10-year period. The study demonstrated that the absence of oropharyngeal symptoms may inaccurately predict the presence or absence of visceral burns on endoscopic evaluation. Others have found that positive oropharyngeal findings correlate with abnormal EGD findings while absence of findings does not guarantee a normal endoscopic exam.[35] This further strengthens the need for a thorough oropharyngeal evaluation by either the initial evaluating ER clinician or, if available, ENT.

Similarly, it has been shown that patients presenting with certain symptoms, including stridor, dyspnea, drooling, abnormal oral cavity findings, dysphagia, and vomiting, were significantly associated with pathologic findings on EGD or imaging and subsequent development of complications.[36,37] Furthermore, when analyzed based on groups of findings (i.e., *laryngopharyngeal* symptoms including dyspnea, stridor, hoarseness, sore throat, and drooling vs. *gastrointestinal* symptoms, including dysphagia, abdominal pain, vomiting, or abdominal swelling and/or tenderness), patients with laryngopharyngeal symptoms were more likely to have sustained significant visceral burns.[36] Other studies have shown that hematemesis, respiratory distress alone, or the presence of at least three symptoms together was always associated with severe lesions (positive predictive value = 1), while the absence of symptoms was always associated with limited or absence of lesions (negative predictive value = 1).[38] Clinical signs and symptoms may not reliably predict the extent of injury, thus EGD within the first 24 h, based on the clinician's assessment, should be considered for definitive diagnosis and may reduce significant morbidity and mortality.[31–33,39–45] As such, early ENT involvement to assess the upper airway and possible laryngeal injury may be important.

## 1.9 | Professional societies' guidelines on the role of EGD in evaluation of caustic ingestion

Given the lack of consensus opinion noted in previously reported studies, there is an opportunity for professional organizations to provide guidance. The World Society of Emergency Surgery recommends emergent EGD in pediatric patients, citing studies supporting early endoscopic evaluation within 24 h to establish injury and determine appropriate therapeutic intervention.[46]

Irrespective of the pH of ingestion, the American Society for Gastrointestinal Endoscopy (ASGE) Standards of Practice Committee, the European Society of Gastrointestinal Endoscopy (ESGE), European Society of Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN), and Italian Society of Pediatric Gastroenterology Hepatology and Nutrition (SIGENP) all recommend EGD within 24 h of caustic ingestion in symptomatic patients to establish injury and determine appropriate therapies.[47–49] Symptoms include any oral lesion, dysphagia, drooling, vomiting, abdominal pain, dyspnea, and hematemesis.

The societies are less aligned regarding whether EGD is necessary in cases of suspected ingestion without evidence of oropharyngeal injury. ESPGHAN/ESGE and SIGENP recommend withholding EGD in asymptomatic patients where close follow-up is guaranteed.[48,49] ASGE recognizes the poor correlation between symptomatic presentation and degree of injury and suggests that performing EGD within 24 h is safe and of reasonable prognostic utility, allowing for early grading and intervention when needed.[41]

Notably absent is a position statement or clinical practice guidelines published by the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) regarding medical management and endoscopic evaluation in the setting of caustic ingestion. This review may serve as a framework for the development of such clinical practice guidelines, outlining future directions for registries that follow patients after caustic ingestion to optimally characterize the epidemiology, risk factors, as well as natural history and progression of those children with caustic injection and to provide clinicians with recommendations for an approach to evaluation and management (Figure 1).

## 1.10 | Role of radiographic imaging and laboratory evaluation

The utility of imaging studies and laboratory evaluation as surrogate measures for EGD has been evaluated. High-quality data are lacking to support computerized tomography (CT) scans as a first-line investigative tool in place of EGD in symptomatic patients following caustic ingestion.[50] It has been suggested that non-invasive CT imaging in adult patients has greater utility than EGD for the evaluation of transmural esophageal and gastric injury and for predicting outcomes following caustic ingestion, including esophageal stricture formation; however, CT is not a substitute for endoscopic evaluation.[51–55] There is significant intra- and interrater variability among radiologists when evaluating adult patients for transmural injury following caustic ingestion with CT imaging[56] Similarly, the extent and severity of injury tend to be underestimated as compared with endoscopic evaluation.[53] The recommendation for CT must be balanced by the radiation exposure associated with this modality. CT imaging may be considered when endoscopic evaluation is not available, or is not a safe option, such as in cases of perforation, supraglottic or epiglottic burns with edema, and third degree burns in the hypopharynx, where perforation would be a significant risk.[49] The SIGENP strongly recommends against CT to replace EGD in the evaluation of caustic ingestion in children.[49]

Similarly, magnetic resonance imaging (MRI) has limited utility during emergent evaluation of patients following caustic ingestions due to accessibility, length of study, necessity for anesthesia in young children, cost, and challenges with adequate mucosal evaluation.[57] However, as a long-term surveillance tool, MRI or MR angiography may be used to guide clinical decision-making and management in these patients,[58] further studies are warranted.

## 1.11 | Use of steroids in the acute management of patients following caustic ingestion

Multiple published studies review the utility of systemic and "topical" steroids (e.g., swallowed or even injected in the post-ingestion healing of a fibrosed, strictured esophagus) in the acute management of caustic ingestion involving both pediatric and adult patients. The mechanism of action of steroids, particularly systemic in this population, has not been fully elucidated.[59–61] Some studies suggest improved outcomes in patients with deep (Grade 2b or greater) or circumferential esophageal burns with the administration of steroids.[62,63] However, other studies point to the limited efficacy of steroids in the prevention of serious esophageal stenosis or improvement in wound healing following caustic ingestion, especially as compared to patients who do not receive steroid therapy and these data are balanced with serious side effects, including perforation, associated with corticosteroid administration.[60,64–66] A systematic pooled analysis suggested that steroids may only be effective when there is concern for significant upper airway inflammation or edema; however, their effectiveness in preventing stenosis was questionable.[64,67] The limited utility of steroids in the early period post-caustic ingestion has been further supported by a recent meta-analysis which demonstrated no significant benefit.[14] Moreover, there is only anecdotal data, and a lack of randomized controlled trials, which evaluate steroid injections in the fibrostenosed esophagus post caustic ingestions. Further studies are warranted before a definitive recommendation, including dosing and duration, can be made for steroid use in acute ingestion.

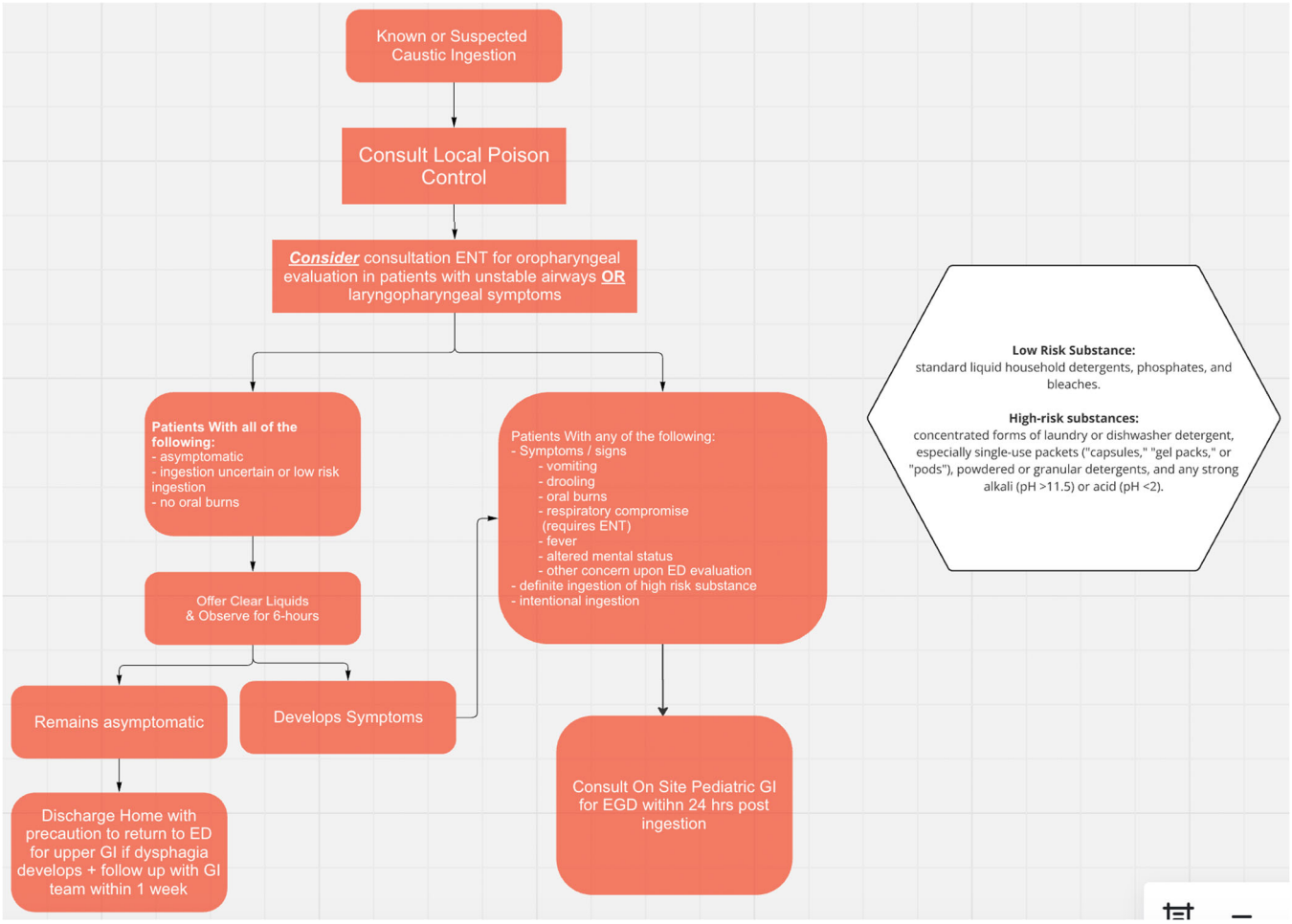



**FIGURE 1** Proposed algorithm for the management of suspected or known caustic ingestion in pediatric patients which includes consults with poison control, pediatric otolaryngology, and/or pediatric surgery (as necessary). ENT, otorhinolaryngology; GI, gastroenterology.

## 2 | ANTIBIOTICS

There is a lack of randomized control trials in humans involving, and limited data on the use of, antibiotics in acute pediatric caustic ingestion. Data suggest minimizing broad-spectrum antibiotic use to those with Grade 3 injuries with concomitant use of steroids or in patients with pulmonary complications[2,67,68].

### 2.1 | Acid suppression

Histamine-receptor blockers or proton pump inhibitors have been utilized to accelerate mucosal healing though data evaluating the efficacy of acid suppression in acute caustic ingestion is equivocal.[16,67] One small-scale study of adults administered intravenous omeprazole found significant differences in endoscopic healing before and after medication use, though larger studies are needed to further qualify these findings.[69] Further, studies in children are lacking and should be employed to determine if there is a benefit of acid suppression in the immediate post-ingestion period.

### 2.2 | Sucralfate

Sucralfate is used to decrease injury associated with acute ulcers by maintaining blood flow to the site of injury, thereby reducing necrosis of esophageal and gastric tissue. Small, randomized trials show promise in the use of sucralfate and its role in decreasing the frequency of stricture formation following caustic ingestion.[70,71] However, due to its adherent properties to mucosal tissue, the administration of sucralfate before EGD may obscure visualization of the mucosa, thus decreasing the utility of endoscopy as a surveillance tool following caustic ingestion. Though it is known to be effective in the case of button battery ingestion by delaying tissue injury associated with this type of ingestion, further research with large, randomized control trials with robust sample sizes will be required to support its use in the setting of caustic ingestion.[72–74]

### 2.3 | Role of nasogastric tube placement

Patients often experience dysphagia and feeding intolerance following caustic ingestion. In patients with superficial esophageal mucosal injury, early initiation of oral feeds may prevent adhesion and stricture formation.[22] However, in patients with more extensive injuries such as circumferential burns, resumption of regular oral feeds may be challenging due to discomfort associated with swallowing and potential irritation to injured mucosa. Endoscopically placed nasogastric (NG) feeding tubes offer an opportunity to safely provide enteral feeds since the tube may be placed under direct visualization at the time of the initial evaluation. In cases of circumferential injury where strictures may otherwise form, the NG tube itself may help maintain the patency of the esophageal lumen thereby reducing the risk of stricture development.[2,22] Animal models similarly demonstrate the prevention of stenosis and further tissue damage when NG tubes are placed shortly after caustic ingestion.[75] Early placement of NG tubes under direct visualization is a practice supported by the World Society of Emergency Surgery preliminary survey of expert opinion on Caustic ingestion management.[27] Despite these potential benefits, there is concern that the NG tube itself could contribute to the development of long strictures.[76] However, this risk appears minimal; thus, NG placement may be a reasonable measure to take in the management of significant (i.e., circumferential ulceration, Zargar 2b and above) caustic injury.

## 3 | SUMMARY

Decades of research have focused on the impact of caustic ingestion on esophageal and upper gastrointestinal health. It should be noted that the majority of these studies, even if purported to be population-based, are typically case series or studies with smaller cohort sizes. Multicenter registries coordinated across national organizations, including the Center for Poison Control, the American Academy of Pediatrics, and the NASPGHAN, should be established to capture population-based data. This will allow for the appropriate characterization of the natural history and progression of patients following caustic ingestion, which will aid in the development of more appropriate, evidence-based clinical guidelines.

## 4 | RECOMMENDATIONS

Given the currently available evidence, it is appropriate to evaluate all symptomatic pediatric patients following caustic ingestion, presenting with oropharyngeal lesions and/or upper respiratory symptoms, with an ENT evaluation and upper endoscopy within 24 h of the ingestion or as soon as the patient is clinically stable. Imaging studies, including CT and MRI imaging, are not suitable alternatives for endoscopic evaluation in the acute evaluation period following caustic ingestion. While there appears to be a limited role for the use of steroids and antibiotics in patients following caustic ingestion, sucralfate may be a supportive measure following endoscopic evaluation. Additional randomized control trials are needed pertaining to the use of antibiotics, steroids, and sucralfate following caustic ingestion. Given the literature reviewed to date, and importance of nutrition for the healing process, inserting an NG tube may be reasonable and appropriate at the time of endoscopy, especially in an attempt to prevent stricture formation in cases of patients with injuries consistent with a grade 2B or higher Zargar scores.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DATA AVAILABILITY STATEMENT

A full list of articles, data, and primary research is available at the end of this report.

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