

Caustic ingestion in children: one year experience in three Italian referral centers

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Abstract

Objectives: Despite the efforts to reduce the exposure to corrosive household products, caustic ingestion in children is currently a significant medical problem. The aims of the present study were to evaluate the clinical consequences of caustic ingestion and to identify prognostic factors that could concur in driving both diagnostic and therapeutic management.

Methods: All consecutive children referred for ingestion of a caustic substance from June 2017 to June 2018 were enrolled. Medical records, laboratory and endoscopic findings were reviewed and analyzed.

Results: We enrolled 44 children with caustic ingestion. Alkaline agents were ingested by 26/44 (59.1%) patients, while acid agents were ingested by 18/44 patients (40.9%). Alkaline rather than acid agents were associated with a worse endoscopic score ($r:0.45$) and a higher probability of early esophageal stricture occurrence ($r:0.38$). The specific risk of the presence of severe esophageal lesions rose progressively with increasing number of symptoms while no esophageal injury was found in asymptomatic patients.

Conclusions: Our data suggest that endoscopic evaluation is mandatory in symptomatic patients to direct therapeutic management, but it could be avoided in asymptomatic patients after accidental ingestion, particularly if the ingestion is only suspected and patients have no oropharyngeal burns.

Keywords: caustic ingestion; endoscopic evaluation; esophageal lesions

What is known

- Caustic ingestion in children is currently a significant medical problem.
- The likelihood that ingestion will result in a serious burn injury is dependent on several factors, including pH, concentration, physical state and viscosity, amount consumed, and length of contact time with the mucosa.

What is new

- Asymptomatic patients have a very low probability to have clinically relevant esophageal injury, whose risk raises with increasing number of symptoms, oral lesions and drooling
- Endoscopic evaluation is mandatory in symptomatic patients to direct therapeutic management, but it could be avoided in asymptomatic patients after accidental ingestion.

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Introduction

Despite the efforts to reduce the exposure to corrosive household products, caustic ingestion in children is currently a significant medical problem. Indeed, potentially catastrophic presentations and lifelong complications resulting from corrosive ingestions are one of the most challenging situations encountered in pediatric medical practice. Caustic material ingestion is most frequently accidental in children, more prevalent in families with low income and in children with mental disorders and cognitive impairments. Teenagers are also at risk but ingestions in this age group are often purposeful.^{1,2}

The likelihood that ingestion will result in a serious burn injury is dependent on several factors, including pH, concentration, physical state and viscosity, amount consumed, and length of contact time with the mucosa. Several studies have shown that clinical signs are not always good predictors of the degree of injury and possible outcome of stricture formation.³⁻⁵

Esophagogastroduodenoscopy (EGD) is usually routinely recommended in patients after caustic ingestion and should be performed to carefully assess the extent and severity of digestive lesions in order to prevent unnecessary hospitalization and to plan future treatment.^{6,7}

Besides perforation, the most serious complication of corrosive damage to the esophagus is stricture formation. Early complications include also bleeding, while other long-term adverse effects are fistula, gastric outlet obstruction, cancer and systemic complications (renal insufficiency, hepatic dysfunction and diffuse intravascular coagulation).⁸⁻¹¹

The main objectives of this prospective study were: 1) to describe the type of the ingested substances, ingestion modalities, clinical symptoms and signs, blood parameters and endoscopic findings, 2) to evaluate the long-term clinical consequences of caustic ingestion, 3) to identify prognostic factors that could concur in driving diagnostic and therapeutic management.

Methods

This multicenter observational study was conducted from June 2017 to June 2018 in the Pediatric Departments of the participating Centers. All consecutive children referred to our Centers

for ingestion of a caustic substance underwent both EGD and routine blood analysis; the endoscopy was performed within 7 to 24 hours from the ingestion. Only patients with an history of acid ($\text{pH} < 2$) or alkaline ($\text{pH} > 12$) corrosive substance ingestion (referred to as “caustic”) were enrolled. The pH was determined in the Emergency Department by litmus paper testing if the product was available or by identifying the substance ingested and finding its safety data sheet or by contacting the National Poison Center. Informed consent was obtained from parents or caregivers.

A medical record was completed for each child by a trained pediatrician, who collected information on the patient demographic and health-related characteristics and on the substance involved, eg, the date of birth, date and time of ingestion, time of the last meal, commercial name and chemical properties and concentration of the substance, accidental or deliberate ingestion, and signs and symptoms (oral burns, dyspnea, vomiting, drooling, dysphagia and hematemesis). Induced vomiting was not considered a symptom and pain was not assessed, because most of the children were unable to give an objective description of this symptom. All patients showing respiratory symptoms were sent to the pediatric otolaryngologist for a laryngoscopic evaluation.

EGDs were always performed under general anesthesia with pediatric endoscopes by expert endoscopists and explored the esophagus, the stomach and the duodenum. Reports were reviewed and graded for severity of esophageal injuries by a physician blinded to the initial symptoms using the Zargar endoscopic classification (supp table [1http://links.lww.com/MPG/B797](http://links.lww.com/MPG/B797)).¹² Blood test including complete blood cell count, biochemical parameters, C reactive proteine (CRP) and arterial blood gas (ABG) values were recorded. Patients with grade 0 and grade 1 esophageal injury were orally fed and discharged 24 h after endoscopy without therapy. Patients with grade 2a were fed with soft cold foods and treated with proton pump inhibitors. Patients with grade 2b and 3 were treated with intravenous antibiotics, proton pump inhibitors, steroids and parenteral nutrition. Barium meal studies were performed in all patients with grade 2b and 3 esophageal lesions at 4 weeks from the ingestion or early if symptomatic and in all patients if symptoms suggestive of esophageal stricture occurred. Esophageal dilations with Savary’s dilator were performed if needed.

Possible predictive factors were tested individually or in groups for their diagnostic value in relation to complications. Categorical data were summarized as frequencies and percentages. Analyses were performed by using the X² test or the Fisher exact test, as appropriate. A *p* value of $\leq .05$ was considered significant and an odds ratio (OR) was calculated with a 95% CI. A multivariate logistic regression analysis was carried out to identify variables independently associated with a third-degree esophageal lesion. Data were analyzed by using the Statistical Package for the Social Sciences (SPSS Inc, Chicago, Ill). The study was approved by the “Cardarelli-Santobono” Independent Ethics Committee and was conducted in accordance with the Declaration of Helsinki and Guidelines for Good Clinical Practice.

Results

Over the study period we enrolled 44 children with caustic substance ingestion (M/F: 25/19; age range: 13-204 months; mean age \pm standard deviation: 60.11 \pm 54.49 months). Of these, 40/44 (90.9%) were children (age 2-12 years), and 4/44 (9.1%) were adolescents (age 13-18 years). Most of the patients were younger than 5 years of age (34/44, 77.3%).

Alkaline agents were ingested by 26/44 (59.1%) patients, while acid agents were ingested by 18/44 patients (40.9%). The most frequent caustic substance ingested was 5% Sodium hypochlorite (household bleach), which was involved in 11/44 cases (25%). Thirty-seven/44 (84.1%) ingestions were accidental, 5/44 (11.4%) were intentional with self-injurious or suicidal purposes, whereas in 2/44 (4.5%) the ingestion modalities were ambiguous. Products accidentally ingested were inappropriately stored in glasses or water/juice bottles in 25/37 (67.6%) cases or were stored in the original container but with removed or unscrewed cap in 10/37 (27%). In 2/37 (5.4%) the information about the ingestion was vague and unreliable.

At admission, 40/44 (90.9%) were symptomatic whereas 4/40 (9.1%) were asymptomatic. The most frequently complained symptoms were vomiting and drooling. The complete list of the reported symptoms is shown in table 1. Sixteen/44 (36.4%) patients presented oral cavity lesions,

especially ulcerations. Finally 3/44 (6.8%) were admitted for respiratory distress. No patient with respiratory symptoms showed laryngeal lesions at laryngoscopic evaluation.

An EGD was performed in all cases at a mean time of 12.7 ± 6.2 hours (range 7-24 hours) after the ingestion. Twenty-one/44 (47.7%) patients had no esophageal lesions (Zargar endoscopic score= grade 0), 7/44 (15.9%) patients had esophageal erythema (Zargar endoscopic score= grade 1), 5/44 (11.4%) patients had non-circumferential superficial ulcerations and erosions (Zargar endoscopic score= grade 2a), 3/44 (6.8%) had deep discrete or circumferential ulcerations (Zargar endoscopic score= grade 2b), 4/44 (9.1%) had multiple ulceration and areas of necrosis (Zargar endoscopic score= grade 3a) and 4/44 (9.1%) had areas of extensive necrosis (Zargar endoscopic score= grade 3b). Gastric injury was reported in 11/44 (25%) patients while duodenal abnormalities were reported in 2/44 (4.5%) patients. Of note, among the 4 children who were asymptomatic at admission, 3 had no esophageal lesions and 1 had grade 1 lesions. Different data on esophagogastric lesion rate according to the different chemical feature of the ingested agent are shown in figure 1.

Increased CRP was found in 10/44 (22.7%) cases whereas 2/44 (4.5%) showed hyperamylasemia. No ABG alterations were registered.

According to the study protocol, all patients with no or mild esophageal lesions (grade 0-I at Zargar endoscopic score) were early orally fed and discharged at home 24 h after endoscopy without therapy. Patients with grade 2a were fed with soft cold foods and treated with proton pump inhibitors whereas patients with grade 2b and 3 were treated with intravenous antibiotics, proton pump inhibitors, steroids and parenteral nutrition.

Fourty/44 (90.9%) patients were followed up 1 month later the admission. The remaining 4/44 (9.1%) patients were lost to follow-up. Among the 40 patients who returned at follow-up, 5/44 (11.4%) were still reporting symptoms, including dysphagia (4/44, 9.1%) and sore throat (1/44, 2.3%). Fourteen/44 (31.8%) underwent barium meal study. Among these, 4/14 (28.6%) were found having early esophageal stricture and underwent dilation, whereas 1/14 (7.1%) reported

gastrectasia. All these 4 patients with esophageal stricture had grade 3 esophageal injuries (3=3b and 1=3a). Demographic features, caustic ingestion features and clinical outcome of patients with grade 3 endoscopic lesions are reported in table 2.

According to the multivariate logistic regression analysis, alkaline rather than acid agents were associated with a worse endoscopic score ($r:0.45$), a greater increase of C reactive protein ($r:0.42$), and a higher probability of early esophageal stricture occurrence ($r:0.38$). The specific risk of the presence of second/third-degree esophageal lesions raised progressively with increasing number of symptoms. Nevertheless, only drooling and oral lesions were statistically significantly related to a worse endoscopic score when considering every symptom alone ($r:0.48$ and $r:0.36$, respectively). Oral lesions were also linked to a more frequent onset of early esophageal strictures ($r:0.5$) and to a higher need of esophageal dilations ($r:0.4$). Children showing respiratory distress were more likely to develop early esophageal stricture ($r:0.44$) and subsequent onset of dysphagia ($r:0.54$). Finally, the blood concentration of C reactive protein and amylase were both positively related to a higher probability of stricture development ($r:0.45$ and $r:0.7$, respectively).

Discussion

Children are exposed to a variety of noxae that can cause severe esophageal damage, as a result of ingested harmful foreign bodies (pointed or sharp objects, magnets, disk batteries) or injurious substances¹³. Accidental caustic ingestion is relatively common in pediatric age, especially among individuals with poor socioeconomic status.^{14,15} Factors favouring this type of accidents are the typical curiosity of this age, the ability to reach increasingly higher areas and handle dangerous objects and the caregivers' negligence along with the common habit of keeping caustic agents in beverage bottles.⁴ In the USA, recent legislative efforts have significantly reduced the incidence of caustic ingestion. Nevertheless, these injuries continue to impose a significant burden on health care resources with an estimated annual economic burden of \$ 22900000 in the

entire USA.¹⁶ In the present study accidentally ingested products were inappropriately stored in glasses or water/juice bottle in 68% of patients and were stored in the appropriate container but with removed or unscrewed cap in 27%. These data support an urgent need for specific laws aimed at avoiding the inappropriate storage of caustic products and the role of scientific societies and paediatricians to educate caregivers and public opinion on the possible dramatic consequences of caustic ingestions and that their prevention require only few but very important precautions.

According to our data, 56% of patients were male and the majority (59%) ingested alkaline substances, however sodium hypochlorite (household bleach), which is widely used in house cleaning in our country, was the most commonly ingested product accounting for 25% of cases itself. Our data confirm the findings of a recent meta-analysis showing that caustic ingestion is more common among boys and that the most commonly ingested substances are alkaline products. Caustic soda was the most common causative agent, followed by muriatic acid.¹⁷ In our series, alkaline rather than acid agents were associated with a worse endoscopic score and a higher probability of esophageal stricture occurrence. This is probably related to the different types of tissue damage induced by acids and alkalis. Acids cause coagulation necrosis, which limits deep penetration. Acidic substances rapidly transit to the stomach because of their low viscosity and specific gravity resulting in gastric more than esophageal injuries. Contrariwise, alkali cause liquefactive necrosis and saponification resulting in deep penetration of tissue, mainly limited to the esophagus.¹⁸ However, the extent of injury following caustic ingestion is related to other factors as well, such as amount, concentration and tissue contact time with caustic substance.⁶

The predictability of esophageal injury based on signs and symptoms, and the necessity of upper gastrointestinal endoscopy has been addressed in previous reports with conflicting results.^{3,5,6,8,11,19,20} Although severe esophageal injuries have been reported from 12 to 26% of asymptomatic children, significant lesions at endoscopy are unusual when symptoms are absent after unintentional ingestion of small amount of less aggressive substances, suggesting that an endoscopy is unnecessary in asymptomatic patients after accidental caustic ingestion particularly if

the ingestion is only suspected and patients has no oropharyngeal burns.^{5,6,10,20,21,22} In our study, 91% of patients were symptomatic, 36% presented sever oral lesions and 7% had respiratory distress. This higher percentage of symptomatic patients as compared to the literature could be explained with the high rate (68%) of “accidental-deliberate” ingestion in our series. Indeed, this ingestion modality occurs in older children who deliberately drink a large amount of the substance contained in a normal beverage bottle, which is accidentally a caustic one.^{6,10,20} We haven't found severe esophageal injury (II/III degree) in the four asymptomatic patients, of which only one patient had grade 1 esophageal injury; instead 40% of symptomatic patients had severe esophageal injury and 12.5% had a grade 1 esophageal injury. Gastric and duodenal injury has been reported in 25% and 4.5 % of patients, respectively; all gastro-duodenal injuries were found in symptomatic patients with no differences between acid and alkaline products.

According to our data, the risk of the presence of clinically relevant esophageal lesions (II/III degree) rose with increasing number of symptoms. Nevertheless, only drooling and oral lesions were statistically significantly related to a worse endoscopic score when considering every symptom alone. Oral lesions and respiratory distress were also linked to a higher probability of stricture development.

Although laboratory tests do not always correlate with severe injury, leukocytosis $> 20,000$ wbc/ml, elevated CRP, $\text{pH} < 7.2$ and a base excess greater than -12 have been linked to a sever esophageal injury.¹⁸ Interestingly, in our study increased CRP concentration and amylase level were related to a higher probability of stricture development.

The most frequent complication of caustic ingestion is esophageal stricture. The rate of stricture formation is reported to vary between 2% and 63%.^{18,23,24} Baskin et al reported that 4.7% of patients with grade 2a injury and 26% of those with grade 2b injury developed esophageal stricture.²⁵ Temiz et al reported an overall incidence of esophageal stricture of 7.8% with esophageal stricture rate of 14.3%, 32.1% and 100%, in patients with grade 2a, grade 2b and grade 3 esophageal injuries, respectively.¹⁰ In our study the overall incidence of early esophageal stricture

was 9%. All these 4 patients had grade 3 esophageal injuries, with a total esophageal stricture rate of 50% in this group. Only one patient with gastric injury reported symptomatic gastrectasia related to a retracted antral scar without pyloric stenosis. The relative low rate of esophageal stricture may probably be related to the short-term follow-up of our study.

In conclusion, in this study we showed that: “accidental-deliberate” caustic ingestion is a relevant social problem needing urgent prevention strategies; alkaline agents are associated with a worse endoscopic score and a higher probability of esophageal stricture development; asymptomatic patients have a very low probability to have clinically relevant esophageal injury, conversely the risk of the presence of clinically relevant esophageal lesions raise with increasing number of symptoms, oral lesions and drooling; despite the endoscopic-guided management of esophageal caustic injuries, the early stricture rate remains high in grade 3 esophageal injuries. Moreover, even if our data refer to a relatively small sample, we must report that CRP and amylase levels were related to a higher stricture risk. Taken together, our data suggest that endoscopic evaluation is mandatory in symptomatic patients to direct therapeutic management, but it can be avoided in asymptomatic patients after accidental ingestion, particularly if the ingestion is only suspected and patients have no oropharyngeal burns.

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Legends

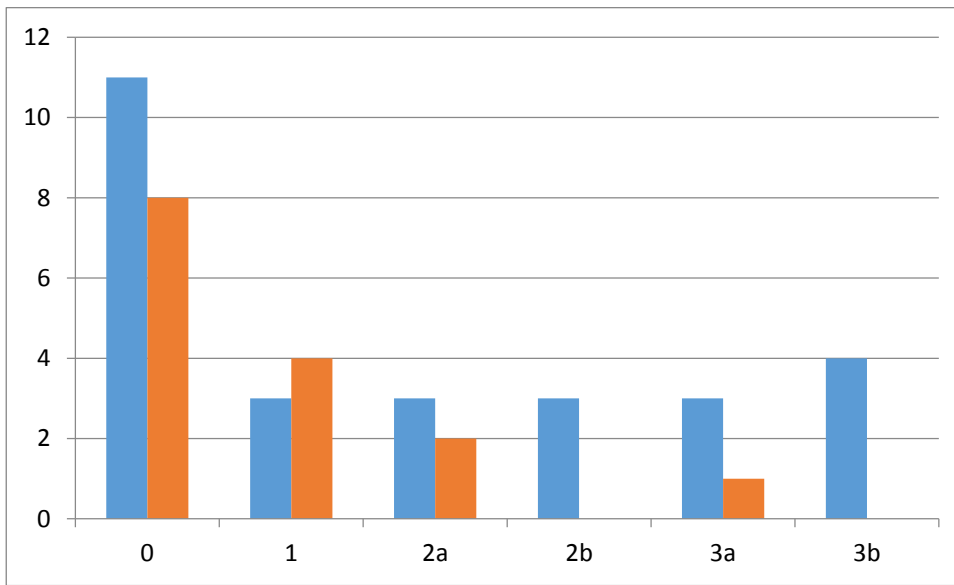


Figure 1. Esophagogastric lesions score according to the different chemical feature of the ingested agent (blue=acid, orange=alkaline; abscisse=Zargar score, ordinates=number of patients)

Table 1. Symptoms reported by the enrolled patients

Symptoms	Number and % of patients
Vomiting	27 (61.4 %)
Drooling	20 (45.5 %)
Heartburn or chest pain	7 (15.9 %)
Hematemesis	5 (11.4 %)
Sore throat	3 (6.8 %)
Respiratory distress	3 (6.8 %)
Cough	1 (2.3 %)

Table 2. Demographic features, caustic ingestion features and clinical outcome of patients with grade 3 endoscopic lesions

	Endoscopic grade	
	3a (n=4)	3b (n=4)
Mean age (months)	43.25	44.5
Male	3 (75%)	1 (25%)
Accidental ingestion	4 (100%)	4 (100%)
Type of substance ingested		
Alkaline	3 (75%)	4 (100%)
Acid	1 (25%)	0 (0%)
Early stricture development	1 (25%)	3 (75%)

Data presented as N (%)