Endoscopic findings of the digestive tract secondary to caustic ingestion in children seen at the Emergency Department

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ABSTRACT

Background. Caustic ingestion in pediatrics is a common cause of visits to the Emergency Department. An indiscriminate use of cleaning chemicals and an easy access to them are determining factors for these injuries.

Population and methods. Descriptive, analytical study. Children aged < 16 years hospitalized between January 1998 and December 2017 were included. The ingested caustic substance was identified as acid or alkaline. A gastrointestinal endoscopy was done to establish the burn grade. The grade of the burn was compared to the type of caustic substance using the χ^2 test or the Fisher's exact test; a P value < 0.05 was considered significant.

Results. A total of 133 children were admitted to the Emergency Department due to caustic ingestion. The caustic agent was acid in 41 % of cases and alkaline, in 59 %. The most common acid caustic substance was muriatic acid (36.8 %) and the most common alkaline caustic agent was caustic soda (41.4 %). An esophageal burn was the most common consequence of caustic soda ingestion compared to other caustic agents ($p = 0.001$), whereas muriatic acid ingestion was the most statistically significant cause of stomach burn ($p = 0.001$) and duodenal burn ($p = 0.002$). The age group that most commonly ingested some caustic agent (93.2 %) corresponded to children younger than 5 years.

Conclusions. The most common type of ingested caustic agent was alkaline, which caused esophageal burn; whereas, the ingestion of an acid caustic substance caused stomach and duodenal burns, as evidenced by endoscopy.

Key words: *caustic agents, gastrointestinal endoscopy, child.*

http://dx.doi.org/10.5546/aap.2018.eng.409

To cite: Barrón Balderas A, Robledo Aceves M, Coello Ramírez P, García Rodríguez E, et al. Endoscopic findings of the digestive tract secondary to caustic ingestion in children seen at the Emergency Department. *Arch Argent Pediatr* 2018;116(6):409-414.

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Funding:
None.

Conflict of interest:
None.

Received: 4-16-2018
Accepted: 7-11-2018

INTRODUCTION

In recent years, the chemical industry has developed a vast number of compounds used for cleaning. An easy access to such powerful cleaning products and the intrinsic characteristics of children have increased the incidence of caustic injuries in children younger than 5 years.[1,2] Actual incidence numbers vary depending on the health system structure of each country. According to some reports, between 5000 and 18 000 cases of caustic ingestion occur every year in the United States of America (USA).[3,4] Depending on exposure, caustic agents may cause gastrointestinal, skin, and eye burns. The severity of damage depends on the type, amount, and concentration of the ingested substance. Alkaline and acid substances have high levels of toxic effects.[5] A pH of less than 2 or more than 12 indicates a caustic agent.[3] Alkaline substances generally cause more severe injuries due to liquefactive necrosis.[5] In children with caustic ingestion, an endoscopy is a reliable technique to assess the mucous membrane of the upper digestive tract and overcome the problem of the scarce correlation between symptoms and injury severity. The endoscopy allows to define the anatomic location and severity of injuries.[6] It is recommended to do it within 24 hours after the event because, after this period, the endoscope may perforate the digestive tract.[7] Short term complications of caustic ingestion include perforation and death, whereas, in the long term, these include stenosis and an increased risk for esophageal carcinoma.[8] Our objective was to

describe the endoscopic characteristics of the digestive tract based on the type of chemical agent ingested by pediatric patients.

POPULATION AND METHODS

The study was conducted at the Pediatric Emergency Department and the Department of Pediatric Gastroenterology of Hospital Civil de Guadalajara "Dr. Juan I. Menchaca." The population included 133 children aged between 1 month and 15 years and 11 months old admitted due to caustic ingestion between January 1998 and December 2017. Caustic ingestion was determined based on indirect history-taking and clinical and endoscopic data at the Emergency Department. The type of substance ingested by the child was determined by asking the parents. In each case, a family member was asked to bring the container of the ingested substance to the hospital to establish its type and pH. The clinical examination included the diagnosis of caustic ingestion if the child had oropharyngeal pain, ptyalism, edema, oral ulcerations, dysphonia, odynophagia, signs of severity, such as retrosternal chest pain, vomiting, hematemesis, and signs of hypovolemic shock.[9] Certified pediatric gastroenterologists did a fiberoptic endoscopy of the digestive tract in the first 24 hours after ingestion, with the patient in a stable condition. Zargar's grading classification[10] was used to establish the endoscopic type of burn (*Table 1*). Inclusion criteria were all children younger than 16 years who attended the Emergency Department and had a history of ingestion of a caustic substance fully identified by the Department's staff and whose pH was determined. Children who ingested a caustic agent mixed with hydrocarbons or some other toxic agent were excluded, as well as those who were identified more than 48 hours after caustic ingestion. Children with caustic ingestion and in whom it was not possible to do an endoscopy within the first 6-24 hours after exposure and patients with shock, clinical data of hollow viscera perforation or upper airway obstruction were ruled out.

Table 1. *Zargar's classification of endoscopic injuries*[10]

Grade	Endoscopic characteristics
0	Normal mucous membrane
I	Edema and hyperemia of the mucosa
II	Friability, hemorrhages, erosions, blisters, whitish membranes, and superficial ulcerations
IIa	Diffuse deep or circumferential ulcerations
IIb	Focal deep or circumferential ulcerations
III	Multiple areas of ulcerations and areas of necrosis
IIIa	Small scattered areas of focal necrosis
IIIb	Extensive necrosis

Statistical analysis

For the statistical analysis, qualitative outcome measures were described as frequency and percentage. Quantitative outcome measures were described as average and standard deviation. For the inferential analysis, caustic exposure was divided into three categories. Alkaline agents included caustic soda; acid agents, muriatic acid; and other caustic agents included any other type. Group differences were established using the χ^2 test or Fisher's exact test. A value of $P < 0.05$ was considered significant. The IBM SPSS Statistics software, version 21, and Microsoft Excel, version 14.4.5, were used.

Ethical considerations

An informed consent was obtained from the children's parents at the time of clinical examination for the endoscopy. The Local Research Council and the Ethics Committee of Hospital Civil de Guadalajara "Dr. Juan I. Menchaca" approved the study protocol because it complied with Section 16, Chapter I, Second Title of the General Health Law Regulations in relation to Health Research in Mexico, which referred to the protection of subjects' confidentiality and privacy as per the Declaration of Helsinki.

RESULTS

Sample characteristics

Out of 133 children with caustic ingestion, 39.1 % (52) were girls and 60.9 % (81), boys. The age group that most commonly ingested some caustic agent corresponded to children younger than 5 years, who accounted for 93.2 % (124) of cases. Patients' mean age was 2 years and 6 months old. Six patients (4.5 %) were in the 6-12-year-old group and 3 (2.3 %), in the older than 13 year-old group. Patients' average length of stay in the hospital was 5.4 days, with a standard deviation of 7.8 hours. Among children who ingested caustic agents (14 cases), 10.5 % had a late complication. The most common complication was esophageal stenosis (7.2 %), followed by gastric ulceration (1 case), cerebral hypoxia (1 case), and death (1 case).

Exposure to a chemical substance and endoscopic characteristics of the digestive tract

In relation to exposure, 79 cases (59 %) corresponded to an alkaline substance and 54 (41 %), to an acid substance. Among alkaline substances, the most common agent was caustic soda; and among acid ones, muriatic acid (*Table 2*).

The endoscopic findings of children with caustic ingestion are shown in *Table 3*.

Children with grade I burns in the airways had ingested muriatic acid (2 patients); in these 2 cases, family members had induced vomiting in the child before rushing to the hospital and this may have caused or worsened the injury, such as a double, entry and exit burn. The main injured regions included the larynx, the epiglottis, and the vocal cords. Oral burns were most common in the group with caustic soda ingestion, but they were not statistically significant. A $p = 0.001$ was reported for esophagus burns with caustic soda, and a $p = 0.001$-0.002, for stomach and duodenum burns with muriatic acid. That is to say, a statistically significant association was observed in esophageal injuries with caustic soda, and in the lower digestive tract, such as the stomach and the duodenum, with muriatic acid.

Figure 1 shows four images of the esophagus and the stomach of children seen at our Department with different injury grades as per Zargar's classification.

DISCUSSION

The younger a child is, the more common home injuries are, including falls, wounds, and toxic ingestion. Since 1966, the World Health Organization (WHO) has reported that developing countries have high rates of injuries in children younger than 5 years.[11] In our study, children with caustic ingestion belonged to the "younger than 5 years old" age group, as reported in the bibliography.[6,12-16] The factors favoring these accidents go from the curiosity typical of this age, the ability to reach increasingly higher areas and handle dangerous objects, caregivers' neglect, and lack of recreational areas at home to an excess trust of parents on their child's ability to avoid accidents.[11] These factors, together with

TABLE 2. *Types of ingested caustic agents*

Agent	Percentage	Frequency
Alkaline		
Caustic soda	41.4	55
Sodium hypochlorite	8.3	11
Potassium hydroxide	5.3	7
Ammonia	4.5	6
Acid		
Muriatic acid	36.8	49
Boric acid	1.3	2
Oxalic acid	0.8	1
Sulfuric acid	0.8	1
Acetic acid	0.8	1
Total	100	133

TABLE 3. *Endoscopic diagnosis of digestive tract burns based of the type of chemical substance ingested*

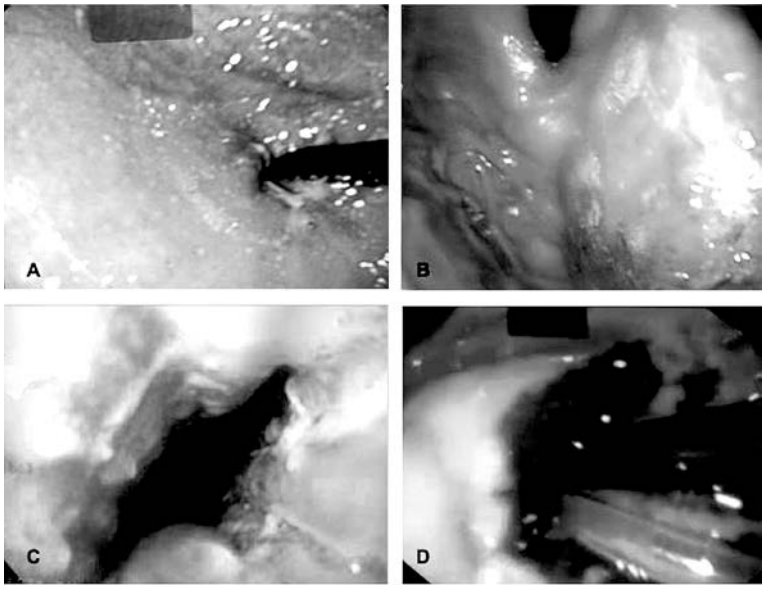
Burn grade as per endoscopic assessment	Alkaline Caustic soda n (%)	Acid Muriatic acid n (%)	Other caustic agents n (%)	P[a]	Total n (%)
Airways (grade I)	0	2 (100)	0	0.11	2 (1.5)
Oral cavity[b]	31 (49.2)	22 (34.9)	10 (15.9)	0.66	63 (47.3)
Grade I[b]	26 (46.4)	20 (35.7)	10 (17.9)	0.74	56 (42.1)
Grade IIa	5 (71.4)	2 (28.6)	0	0.60	7 (5.2)
Esophagus[b]	48 (50)b	36 (37.5)	12 (12.5)	0.001	96 (72.1)
Grade I[b]	25 (51)	18 (36.7)	6 (12.3)	0.001	49 (36.8)
Grade II a[b]	12 (46.1)	11 (42.3)	3 (11.6)	0.02	26 (19.5)
Grade II b[b]	10 (55.5)	5 (27.7)	3 (16.8)	0.005	18 (13.5)
Grade III a	1 (50)	1 (50)	0	0.28	2 (1.5)
Grade III b	0	1 (100)	0	0.60	1 (0.8)
Stomach	8 (32)	16 (64)b	1 (4)	0.001	25 (18.7)
Grade I	6 (37.5)	10 (62.5)	0	0.01	16 (12)
Grade II a	1 (14.3)	5 (71.4)	1 (14.3)	0.02	7 (5.2)
Grade III a	1 (100)	0	0	0.92	1 (0.8)
Grade III b	0	1 (100)	0	0.17	1 (0.8)
Duodenum	1 (12.5)	7 (87.5)b	0	0.002	8 (6)
Grade I	1 (14.2)	6 (85.7)	0	0.02	7 (5.2)
Grade II a	0	1 (100)	0	0.42	1 (0.8)

a: Fisher's test; b: χ^2 test; P= < 0.05.

the common habit of keeping caustic agents in inadequately labeled beverage bottles or food packets, probably favor this type of accidents.[16-19] Unfortunately, there is no precise guideline or formula to prevent children from coming into contact with these chemical substances. In a study by Nuutinen, the author refers that caustic ingestion reduced significantly in Finland since 1969 due to the control and limited sale of these products.[20] In countries like China, for a long time, the use of child-resistant containers for cleaning products to reduce the incidence of these injuries has been advocated.[13] However, in the USA, a country that has adopted such control and safety measures for containers, an analysis of the 1990-2006 period showed that caustic ingestion was common at an age similar to that reported in the bibliography: children younger than 5 years, with a maximum peak at 1-3 years old. Adequately labeled products, especially in spray bottles, increased from 30 % to 40 % as a cause of burns or toxicity in children. This means that children who had some toxic contact with these products were the same who frequently handled the chemical substance or who referred that they had seen their parents using it.[6] Such characteristic supports the hypothesis that curiosity at this age and, most of all, caregivers' neglect are the main causes of these accidents. In developing countries, the role of pediatricians in the prevention of caustic ingestion is not limited to warning parents that they should keep these products out of the reach of children, it also includes encouraging regulations to avoid the free sale of these products in inadequate and unlabeled containers.

Johnson, in 2012, published a report on the impact of caustic ingestion on public health in the USA, which accounted for an expenditure of USD 28 860 per case in average, with an average length of stay of 4.13 days.[7] In our study, we did not assess expenditure per case, because the health care system in Mexico was funded by the Government in the framework of the Popular Insurance Program, but we analyzed the length of stay, which was 5.4 days in average, similar to that observed by Johnson. Temiz, in 2012, in Turkey, observed that patients with grade I and II digestive tract burns had an average length of stay of 5 days, similar to what was observed in this study and that by Johnson, but in the case of grade IIIa or IIIb burns, the length of stay increased up to 15 days in average due to complications.[14] Although, in this study, the length of stay was not classified according to the endoscopic grade of the burn, most of the children had grade IIb burns, and less than 5 % (5 cases) had grade IIIa or IIIb burns in the esophagus and

Figure 1. *Endoscopy images*



A) Erythema of the gastric fundus, grade I injury. B) Blisters, whitish membranes, and diffuse deep superficial ulcerations of the gastric fundus, grade IIa injury. C) Circumferential ulcerations in the middle third of the esophagus, grade IIb injury. D) Areas of diffuse necrosis in the gastric fundus, grade IIIa injury.

the stomach; for this reason, probably, the length of stay was probably shorter.

In a meta-analysis of 64 articles published in 2016, it was observed that caustic ingestion was more common among boys, with an average of 42 % (95 % confidence interval [CI]: 0.29-0.57). However, such difference was not statistically significant,[21] similar to what has been observed in our study, with a slight trend towards male gender, but it was not considered a risk factor. That study also reported that the most commonly ingested substances in the analyzed articles were alkaline substances. Caustic soda was the most common causative agent, followed by muriatic acid.[21]In our study, caustic soda was the most commonly ingested product in 55 cases (an alkaline product), followed by muriatic acid (49 cases). Yanowsky, in a descriptive study also conducted in our city, reported that 82.8 % of children who ingested caustic agents had ingested liquid caustic soda, followed by muriatic acid,[12] as observed in our study, which evidences a clear health problem in Mexico. In this country, there is no law establishing a limit for cleaning product concentration levels, especially for small stores where these products are sold in bulk, unlabeled, and in unsafe containers.

The endoscopic assessment of the digestive tract showed that most injuries corresponded to grade I, IIa, and IIb for caustic soda, and 20 % of these children (11 cases) had esophageal stenosis as a late complication, similar to the reports of Sánchez et al. in 2010.[22] Riffat, in 2009, reported that 50 % of patients with grade II injuries then developed esophageal stenosis. Liquid caustic soda does not have a strong taste, which favors its ingestion, unlike acid substances, which have a more bitter taste. In addition, its aqueous consistency facilitates its adhesion to the narrow areas of the esophagus, such as the cricopharynx, the narrowing at the level of the main left bronchus, and the lower esophageal sphincter, which causes deeper injuries in these areas due to mucous liquefaction, necrosis, and penetration into the muscle.[5,23] During the endoscopic assessment of the digestive tract of the children in our study who ingested muriatic acid, grade I and II injuries were observed in the stomach and the duodenum. In 2012, Temiz reported that the rate of stomach injuries was higher and statistically significant in the group of children who ingested acid substances compared to those who ingested alkaline agents, as observed in this study.

Acid substances cause clotting-related injuries, which limits the deep penetration of tissues. Due to their low viscosity, these substances rapidly reach the stomach.[14]Because of these factors, acid agents cause injuries at the lower levels of the digestive tract, such as the duodenum.

The clinical symptoms of children with caustic ingestion, such as ptyalism, oral pain, vomiting, and oral ulcerations, are not predictors of more severe injuries. An endoscopic assessment in the first 24 hours after the event is the most effective technique to establish the severity of the injury and may be prognostic of late complications, especially in the esophagus.[7,13-15,18,21,23,24]

The weakness of our study is that, during history-taking, it was not possible to determine the amount of chemical substance ingested by the child, which may have helped to explain the characteristics of injuries observed in the endoscopy.

CONCLUSION

Alkaline chemical substances cause injuries in the upper digestive tract and the esophagus, whereas acid agents damage the lower part, including the duodenum, due to their chemical characteristics. ■

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