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Ingestion of Corrosive Chemicals in Children: 8-Year Experience at Amirkola Children's Hospital

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ABSTRACT

Background and Objective: Ingestion of corrosive substances in children is associated with complications and costs to the health care system. The aim of this study was to determine the incidence and complications of ingesting corrosive substances in children.

Methods: This cross-sectional study was conducted on children aged 6 months to 14 years who underwent upper endoscopy at Amirkola Children's Hospital during 2014-2021 for complaints of corrosive ingestion. Information studied included demographic information, type of corrosive substances, clinical symptoms, endoscopic findings, complications, and laboratory results.

Findings: In the 79 children (mean age of 31.33±20.38 months), 65.8% were boys, the most common type of ingested substance was alkaline (86.1%) and the most common ingested substance was bleach (69.6%). Totally, 70.1% of children had symptoms. The most common clinical symptoms were vomiting (68.4%) and oral lesions (39.2%). The esophagus (59.5%) was more affected than the stomach, and the most common esophageal endoscopic finding was grade 1 esophagitis (45.6%). No significant relationship was found between clinical symptoms, the incidence of esophageal-gastric involvement, or the severity of esophageal involvement. Leukocytosis (p=0.009), the increase in C-reactive protein (CRP) (p=0.001), erythrocyte sedimentation rate (ESR) (p=0.007), and blood sugar (BS) (p=0.019) were significantly related to the severity of esophageal involvement.

Conclusion: The results of the study showed that the rate of dangerous side effects caused by ingestion of corrosive substances was not high in children, but often caused by the use of alkaline drain openers, so attention and appropriate diagnostic measures are recommended, as well as preventive measures.

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Introduction

Corrosive substances are widely used and readily available in our daily lives [1]. They are associated with harm when the pH is above 12 or below 2 [2]. The incidence of substance ingestion in children is 5 to 518 children per 100,000 people per year [3, 4], which includes about 80% of children who have ingested corrosive substances [1]. Most corrosive substances are ingested by children younger than 5 years [5-8] in the home setting and accidentally [5, 9-11]. In addition, the ingestion of these substances is more common in male children, with attention deficit or hyperactivity, with the age and low educational level of parents who live in rural areas [5, 9-11]. Corrosive substances include acidic and alkaline substances, and alkaline substances are the most common substances ingested by children [12]. The degree of burns caused by these substances depends on the type, dose, concentration, duration of action of the corrosive substances, and individual characteristics of the patient's body [1]. The spectrum of clinical symptoms of corrosive ingestion in children ranges from asymptomatic to cancer and death [13-15].

Approximately one-half to two-thirds of children are asymptomatic after ingestion of corrosive substances [16]. However, extensive damage to the lips, oral cavity, pharynx, upper respiratory tract, and severe bleeding, perforation of the gastrointestinal tract, stenosis of the trachea, tracheoesophageal fistula (TEF) can occur [13]. Thus, 20% to 40% of cases involving ingestion of corrosive substances may be associated with esophageal damage [17, 18], and 1% of cases are associated with esophageal cancer of the adenocarcinoma type [14] and squamous cell carcinoma [19]. Finally, the mortality rate in children after ingestion of corrosive substances (0 to 0.6%) is much lower than in adults [15, 20].

Children show different symptoms after ingestion of corrosive substances. According to researchers, the relationship between clinical symptoms and the severity of esophageal and gastric involvement is inconsistent [21-25]. Some researchers reported that increased salivation and dysphagia are the most common symptoms and predictors of esophageal stricture in the long term. Vomiting blood is also considered an indicator of the extent of damage [16]. Therefore, despite these symptoms, they recommend a more detailed examination to determine the severity of the injury [26, 27]. Other researchers, however, have not found a specific relationship between symptoms and the severity of the injury [23, 24, 28].

Of course, the absence of vomiting, salivary secretion, and burns of the oral cavity does not exclude esophageal injury and involvement, because sometimes esophageal involvement occurs without damage to the oral mucosa [12]. In this situation, it is difficult to control the ingestion of corrosive substances, and in these cases, endoscopy is a reliable technique to solve the problem of the lack of correlation between clinical symptoms and the severity of the injury [29].

Considering the importance of this issue and the lack of recent studies in this field in the last 5 years, the aim of this study was to investigate the incidence and complications of corrosive chemical ingestion in children referred to Amirkola Children's Hospital.

Methods

Study type and samples

This cross-sectional study was conducted on children referred to Amirkola Children's Hospital with complaints of chemical corrosive ingestion from 2014-2021. Based on inclusion criteria, sampling was conducted by census. Inclusion criteria included children aged 6 months to 14 years without chronic gastrointestinal disease and immunodeficiency who underwent upper endoscopy due to ingestion of corrosive substances. Exclusion criteria included burns of the pharynx and nose, unstable vital signs, and deficiencies in records.

Data collection

All children referred to the hospital with suspected ingestion of corrosive substances during the study period were examined by a gastroenterologist and underwent endoscopy after clinical examinations and laboratory results if further investigations were needed.

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Endoscopy evaluation

All endoscopies of the study were performed by two pediatric gastroenterologists (second and third authors) using a flexible esophagogastroscope (made in Japan). Endoscopic manifestations of esophageal lesions were graded according to the criteria of the Zargar classification for corrosive injuries [8].

In this criterion, depending on the severity of the lesion, the esophagus is classified into 7 grades: Grade 0: normal mucosa, Grade 1: hyperemia and mucosal edema, Grade 2A: superficial and linear erosions, hemorrhages, white membrane on mucosa, Grade 2B: deep and annular ulcers on mucosa, Grade 3A: necrotic areas and multiple ulcerations on mucosa, Grade 3B: extensive mucosal necrosis, Grade4: perforation. This criterion is graded from grade zero, which is normal esophageal mucosa, to grade four, which is perforation of the esophagus. Endoscopic findings of the stomach included normal mucosa, edema and hyperemia, superficial erosions, ulcers, and necrosis [8].

All children participating in the study were followed up for approximately 6 months after discharge. In addition, children who had grade A2 or higher esophagitis at endoscopy were visited under upper GI series approximately 3 weeks after ingestion of corrosive substances to assess long-term (chronic) complications and the need for repeat endoscopy. Acute complications caused by corrosive substance ingestion (pneumonia, mediastinitis, peritonitis, and fistula) and chronic complications (stenosis and fistula) of the child were recorded.

Evaluation of laboratory markers

After the child was admitted to the hospital, laboratory markers such as complete blood count, sodium and potassium, creatinine, urea, blood urea nitrogen (BUN), blood sugar (BS), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) and venous blood gas (VBG) were measured. A test tube containing ethylenediaminetetraacetic acid (EDTA) and a Sysmex cell counter were used for complete blood cell count.

Children's plasma samples and electrolyte analyzer were used to measure sodium and potassium. An audit kit was used to measure BUN and Cr. ESR was measured with a sediment pipette (in this method, erythrocyte (RBC) is measured after one hour of sedimentation). The biochemical method and the Biorex kit were used to measure CRP. VBG measurement was performed with the Media device. All tests were performed at Amirkola Children's Hospital (The normal range of tests was taken from the book by Nelson 2020) [30].

In the present study, in addition to endoscopic information (esophageal and gastric grade) and laboratory parameters, information on clinical symptoms such as (dysphagia, drooling, vomiting, fever, abdominal pain, chest pain, cough, tachypnea, oral lesions), information on the ingested corrosive substance, and demographic data (age, gender) were collected.

Statistical analysis

After collecting the data, they were entered into SPSS23 and analyzed with descriptive indicators such as frequency, frequency percentage, mean, and standard deviation, where $p < 0.05$ is considered significant. The chi-square test was used to test for possible associations.

Results

During the study period, 79 children who had complained of ingesting corrosive chemicals were studied. The mean age of the children was 31.33 ± 20.38 months and 52 (65.8%) were boys and 27 (34.2%) were girls. Regarding the type of substances ingested, 68 children (86.1%) ingested alkalis and 11 ones (13.9%) ingested acids. The most common ingested substance by 55 children (69.6%) was bleach, followed by 9 individuals (11.4%) who ingested drain openers, and 9 other children (11.4%) who ingested cleaning agents (Man). Sodium hydroxide accounted for 86.1% of the corrosive substance ingestion among the children in the study.

On endoscopic evaluation and examination of the esophageal lesion, the results of the study showed that of the 79 children, 32 (40.5%) had normal esophagus and 47 (59.5%) had esophageal lesions. Of the children with esophageal lesions, 36 (45.6%), 9 (11.4%) and 2 (2.5%) had grade 2B esophagitis, respectively (these two children were 5

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and 7 years old and had ingested the alkaline drain openers). Moreover, 46 (58.2%) children had no lesions and 33 (41.8%) children had lesions on endoscopic examination of the stomach. Of the children with lesions, 15 (19%) had gastric edema and hyperemia, 17 (21.5%) had erosive gastric lesions, and one (1.3%) had necrotic gastric lesions, caused by swallowing the alkaline drain openers. On endoscopic examination of the duodenum, 78 (98.7%) children had no duodenal lesions, but 1 (1.3%) child had duodenal involvement from ingesting an alkaline drain opener (table 1).

During follow-up for long-term complications, 2 children (2.5%) had esophageal strictures after hospitalization (in fact, esophageal stricture was initially diagnosed by an upper GI series and confirmed by endoscopy). On initial endoscopic examination, both had grade B2 and the substance swallowed was alkaline drain opener. Overall, 67 of the children studied had at least one clinical finding. Of the children with clinical symptoms, 54 (68.4%), 14 (17.7%), 8 (10.1%), 7 (8.9%) and 5 (6.3%) had vomiting, drooling, abdominal pain at the time of admission, fever and cough, respectively. No significant relationship was found between the presence of symptoms and esophageal or gastric involvement at endoscopy (p=0.418). On examination of the mouth and pharynx, 31 (39.2%) children had oral and pharyngeal lesions, 28 and 3 of whom ingested alkalis and acids, respectively.

When laboratory markers were examined, the results of the study showed that 15 (19%), 19 (24.1%), 8 (10.1%), and 4 (5.1%) children had leukocytosis, elevated BUN, creatinine, and hypernatremia, respectively. In addition, ESR, CRP and BS were increased in 15 (19%), 8 (10.3%) and 13 (16.7%) children, respectively. Leukocytosis (p=0.009) and elevated CRP (p=0.001), ESR (p=0.007) and BS (p=0.019) were significantly related to the severity of esophageal involvement (table 2).

Table 1. Relationship between the type of corrosive substance and the severity of gastro-esophageal involvement

Type of corrosive substance	Severity of gastric involvement- Number%				p-value	Severity of esophageal involvement- Number%			p-value
	Non	Edema and hyperemia	Erosions	Necrosis		Non	Grade 1 esophagitis	Grade ≥2A esophagitis	
Alkali	41(60.3)	10(14.7)	16(23.5)	1(1.5)	0.105	30(44.1)	30(44.1)	8(11.8)	0.175
Acid	5(45.5)	5(45.5)	1(9)	0(0)		2(18.2)	6(54.5)	3(27.3)	

Table 2. Relationship between laboratory markers, the type of corrosive substance and severity of esophageal involvement

Laboratory markers		Type of corrosive substance- N%			Severity of esophageal involvement- Number%			
		Alkali	Acid	p-value	Non	Grade 1 esophagitis	Grade ≥2 esophagitis	p-value
WBC	leukocytosis	13(86.7)	2 (13.3)	0.941	3 (20)	7 (46.7)	5 (53.3)	**0.009**
	Normal	55 (86)	9 (14)		29 (45.3)	29 (45.3)	6 (9.4)	
BUN	Increased	17(89.5)	2 (10.5)	0.624	5 (26.3)	11 (57.9)	3 (15.8)	**0.371**
	Normal	51(85)	9 (15)		27 (45)	25 (41.7)	8 (13.3)	
Creatinine	Increased	7 (87.5)	1 (12.5)	0.902	2 (25)	3 (37.5)	3 (37.5)	**0.133**
	Normal	61 (86)	10 (14)		30 (42.3)	33 (46.5)	8 (11.2)	
Sodium	Hyper/hyponatremia	5 (100)	0 (0)	0.649	1 (25)	4 (75)	0 (0)	**0.819**
	Normal	63 (85.1)	11 (14.9)		31 (41.9)	32 (43.2)	11 (14.9)	
Potassium	Hyperkalemia	9 (90)	1 (10)	0.701	4 (40)	5 (50)	1 (10)	**0.948**
	Normal	59 (85.5)	10 (14.5)		28 (40.6)	31 (44.9)	10 (14.5)	
ESR	Increased	13 (86.7)	2 (13.3)	0.941	8 (53.33)	3 (20)	4 (26.66)	**0.007**
	Normal	55 (86)	9 (14)		24 (37.5)	33 (51.6)	7 (10.9)	
CRP	Increased	7 (87.5)	1 (12.5)	0.891	1 (12.5)	1 (12.5)	6 (75)	**0.001**
	Normal	60 (85.7)	10(14.3)		31 (44.3)	35 (50)	4(5.7)	
BS	Increased	12 (92.3)	1 (7.7)	0.763	5 (38.5)	3 (23.1)	5 (38.4)	**0.019**
	Normal	55 (86)	9 (14)		25 (39)	33 (51.6)	6 (9.4)	

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Discussion

The aim of the ongoing study was to determine the incidence and complications of corrosive chemical ingestion in 79 children admitted to Amirkola Children's Hospital from 2013 to 2014. The results indicated that the most commonly ingested corrosive substances were alkalis (bleaching agents). The most common clinical symptoms were vomiting and oral lesions, and the most common site of endoscopy was the esophagus. It was also found that increased CRP, ESR and BS and leukocytosis were indicators of severe esophageal involvement at endoscopy.

The results of the current study revealed that the most commonly ingested substances were alkalis (bleach). Similar to the present study, in the studies by Ramírez et al. and Almanza-Miranda et al. [2, 31], approximately 60% and 80%, respectively, of the substances taken were alkalis [2, 31]. In contrast, 61% of the children in the study by Chibishev et al. [32] and 100% of the Arab children in the study by Arévalo-Silva et al. [33] ingested acids. The higher prevalence of alkali ingestion in the present study may be due to the use of more alkaline compounds in the manufacture of household cleaners. Furthermore, when alkaline substances were used, YALÇIN et al. and Lovera et al. reported, in agreement with the results of our study, that about 45 of the children ingested bleach-type alkalis [34, 35].

On the other hand, the studies by Yen et al. [36] and Sharif et al. [22] showed that toilet (26%) and bath (19.4%) detergents had the highest prevalence of ingestion. The use of various detergents with different compositions or different access to several detergents may account for this difference in the results.

The most common clinical symptoms in the children studied were vomiting and oral lesions, respectively. In the study by Almanza-Miranda et al., oral lesions, drooling and vomiting were the most common symptoms, respectively [31]. In the study by Mahmoud et al., children had dysphagia, vomiting, drooling and oral lesions, respectively [37]. In addition, there was no significant relationship between clinical symptoms and severity of esophageal involvement at endoscopy. Chen et al. and Ramasamy et al. also stated that symptoms were not predictors of severity of involvement [23, 24].

Furthermore, other investigators also reported similar results [2, 28, 38]. On the other hand, dysphagia in the study by Havanond et al., hematemesis, fever, and abdominal pain in the study by Sharif et al., and cough in the study by Honar et al., were significantly related to the severity of esophageal involvement [21, 22, 25]. Considering that in the present study, the rate of severe esophageal involvement was higher in children with symptoms of oral lesions and vomiting (although this was not statistically significant), the small sample size may be the reason for this lack of association.

The findings after endoscopy indicated that the esophagus was more affected than the stomach and duodenum. Moreover, the most common degree of damage in the esophagus was grade 1 esophagitis and in the stomach, erosive lesions. In addition, no significant relationship was found between the type of substance (acid or alkali) and the site of involvement (esophagus or stomach). This result is consistent with a number of studies such as the studies by Mahmoud et al. and Demirören et al. [8, 37, 39, 40]

On the contrary, some studies reported a significant association between ingestion of an alkaline substance and the development of severe esophageal involvement and eventually the occurrence of esophageal stricture [20, 23, 36, 38, 41], citing the cause of condensation necrosis by alkali and the deep penetration of alkali into the tissue [42]. Ingestion of more alkaline substances due to their tastelessness may be one of the causes of the association between alkaline substances and severe esophageal involvement.

In the present study, a significant relationship was found between the severity of esophageal involvement on endoscopy with increased ESR, BS and CRP, and leukocytosis. In the studies by Mahmoud et al., Kaya et al., and Havanond et al., a significant relationship was found between leukocytosis >20,000 with severity of esophageal involvement and mortality [22, 25, 28, 37, 43, 44].

Although several studies reported that there was no significant relationship between leukocytosis and severity of esophageal involvement [23, 38], Di Nardo et al., Chen et al. and Uygun et al. suggested that

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there was a significant relationship between increased CRP and severity of esophageal involvement [23, 28, 41]. The possible reason for this is that when esophageal damage is severe, inflammatory markers such as ESR, CRP, and WBC increase due to more inflammation. The ingestion of corrosive substances by children usually is due to the availability of these substances and the negligence of mothers; therefore, it is suggested to educate mothers (unavailability of detergents) to prevent the ingestion of corrosive substances by children. It is also recommended that manufacturers of these materials provide bottles containing corrosive substances with tight lids.

Limitations of the study

One of the limitations of the study is that the study was retrospective and the number of samples was limited. Therefore, it is suggested that a long-term cohort study with long follow-up should be conducted to investigate the results according to the type of corrosive substance.

Conclusion

The findings of the present study indicated that the most commonly ingested corrosive substances were alkaline (bleach), the most common clinical symptoms were vomiting and oral lesions, and the most common site of involvement in endoscopy was the esophagus. No correlation was found between clinical symptoms and severity of esophageal involvement on endoscopy. Furthermore, the results of this study demonstrated that leukocytosis and increased CRP, ESR, and BS were indicators of severe esophageal involvement at endoscopy. Although the incidence of dangerous complications (stenosis, rupture and esophageal fistula and death) is low, monitoring patients and taking timely and appropriate diagnostic and treatment measures based on existing guidelines are helpful and necessary.

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Ethical considerations

This study was approved by Ethics Committee of Babol University of Medical Sciences with the code MUBABOL.HRI.REC.1400.034.

Conflict of interest

There was no conflict of interest.

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