



Caustic Ingestion in Children: a Systematic Review and Meta-Analysis

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ARTICLE INFO

Article Type:

Original Article

Article History:

Received: 23 May, 2015

Accepted: 2 Oct. 2015

ePublished: 1 Sep. 2016

Keywords:

Caustic ingestion
Systematic review
Meta-Analysis
Children

ABSTRACT

Introduction: Caustic ingestion that occurs accidentally is one of the most common problems in children.

Methods: This systematic review has been performed by searching the databases including Science Direct, ProQuest, Google Scholar, and PubMed. A strategic search was performed with keywords including caustic, corrosive, ingestion, and children, and was limited to articles in English and Persian. Data were analyzed using Comprehensive Meta-Analysis2 and PASW Statistics 18.

Results: We selected 64 articles regarding caustic ingestion with a total sample of 11,345 cases. The data analysis indicated a higher consumption in young boys (age range 2.78 (2.02) years (OR=0.53 with a 95% confidence interval of 0.49-0.57 (P=0.08)). The most common caustic substances were household cleaning agents, particularly bleaches and cleaners. Esophageal cancer and death were reported as well as digestive and respiratory complications. Invasive and expensive techniques are frequently used for diagnosis, treatment and follow up.

Conclusion: The results demonstrated that although caustic ingestion is a serious problem among children, it is a preventable and manageable issue. Therefore, appropriate efforts by families, government, factories, health team and media should be made to handle adequately this matter.

Please cite this paper as: Rafeey M, Ghojzadeh M, Sheikhi S, Vahedi L. Caustic ingestion in children: a systematic review and meta-analysis. J Caring Sci 2016; 5 (3): 251-65. doi:10.15171/jcs.2016.027.

Introduction

Caustic ingestion by children is still a serious medical and social issue.¹ Ingestion of caustic agents leads to injuries in the esophagus, pharynx, larynx, and mouth, which often lead to death or other adverse effects on the gastrointestinal and respiratory tracts.²

Ingestion of caustic agents are frequently reported in children,^{3,4} especially when children start to walk or crawl. Therefore these accidents were considered as one of the main causes of death in children less than 5 years with the peak incidence at 2 years of age.

However, these incidents also were observed in lower than one years old children.⁵ Annually, more than 40,000 cases of caustic ingestion in children are reported in England and Wales.⁶ In Galsya, with a population of half a million children under the age of 14 years, 4.8% of the annual medical service admissions were associated with caustic ingestion in children.⁷ It is still common in children of the United States, despite the declining of caustic ingestion in (5,000 to 15,000 reductions per year), with incidence of 15.8 cases in every 100,000 persons.⁸⁻¹⁰ From 2005 to 2006, 10% of the 51 children admitted

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to the department of pediatrics, Children's hospital of Tabriz, Iran, had stenosis and gastric outlet obstruction following ingestion of caustic agents.¹¹ However, prevalence of these accidents in our area is unknown. In a retrospective study conducted between 2002 and 2004, 74.7% of the 72 children admitted at the department of pediatrics, Lohman Hakim hospital of Iran, were reported to be due to accidental ingestions.¹²

There are more than 500 toxic substances at home that most of them were kept at the kitchen without considering appropriate storing points.⁵ Additionally, most of ingestions are due to consumption of household chemicals, such as detergents and bleaches.^{6,7} On the other hand, the swallowing of these agents could lead harmful health consequences and impose an economic burden for measurement, treatment, follow up and caring.^{6,11,13,14} Esophageal stricture is considered a short-term effect, but esophageal perforation, esophageal obstruction and cancer could be some of the long-term effects of ingestion of caustic agents.¹⁵⁻¹⁷

Although the ingestion of caustic materials is a simple preventable problem, but it has continued in most developing countries.^{2,9} Families, manufacturing, government and health staff have a major role in the control and management of these accidents.^{5,9,18,19} Persist and ongoing communication among these teams could reduce the rate of accidents or modify the course of the disease.^{18,20} The aim of study was to evaluate age distribution, sex ratio type of caustic agents, signs and symptoms, complications, and management of caustic ingestion in children by a systematic review and meta-analysis research method. Also, we are going to determine the maximum events according to age and sex and the adverse agents and toxic effect that utilizing appropriate preventive strategies would be effective against accidental caustic ingestion.

Materials and methods

This study was performed to review the studies on caustic ingestion in children to

determine the prevalence of age, sex ratio, and complications in children. We conducted a systematic review of papers published since 1980, in four phases. These involved planning the search strategy and performing the search, collection of articles and systematic review, evaluation of inclusion and exclusion criteria, and data analysis. These phases are described in the following sections.

In the first step, Springer, Science Direct, ProQuest, Google Scholar, and PubMed search randomly following the PRISMA guidelines was made for articles on caustic ingestion in children. Studies published in English or Persian from 1980 to July 14, 2013 were reviewed. The keywords used were caustic, corrosive, ingestion, and children, and by Medical Subject Headings (Mesh) for medical science databases with the cooperation of a gastroenterology pediatric subspecialist, physiologist, PhD by Research, and clinical librarian. The following search strategy was employed for PubMed:

Caustics" [Pharmacological Action] or "caustics" [MeSH Terms] or "caustics" [All Fields] or "caustic" [All Fields] or "caustics" [Pharmacological Action] or "caustics" [Mesh Terms] or "caustics" [All Fields] or "corrosive" [All Fields] and "eating" [Mesh Terms] or "eating" [All Fields] or "ingestion" [All Fields] and "child" [Mesh Terms] or "child" [All Fields] or "children" [All Fields].

- Focus question:

The focus question was established according to the PICO (population, intervention, comparison, and outcome)

Format: In patients with caustic ingestion in children

- P (population): patients with caustic ingestion in children.

- I (intervention): -

- C (comparison): Age, sex, and complications in children

- O (outcome): Patients who referred to hospital

- Inclusion criteria:

In the second phase, all eligible studies were separately surveyed by two expert appraisers to evaluate article equality, minimize bias, and

to excluded irrelevant studies (e.g., related to adults, swallowing batteries, and drug abuse, which were excluded due to low quality) based on agreement between the appraisers. Related studies were included, and then debatable articles were referred to the third appraiser. Kappa agreement rate was higher than 85%. Finally, kappa agreement was considered as inclusion criterion for the next phase.

- Exclusion criteria:

In the third phase, irrelevant studies, systematic articles, case control articles, cohort articles, clinical trial articles, animal studies, kappa agreement rate less than 84%, duplicated articles, and letters were excluded from the sample. In addition, the articles which obtained manually from the references of the previously selected articles were added to the set. Figure 1 shows the process of manuscripts' selection.

In the fourth phase, all papers were divided in two categories (quantitative and qualitative). The summary of the four phases

are shown in table 1.

The data was summarized in an extraction table using the Microsoft Office Excel software, and were then analyzed using Comprehensive Meta-Analysis (CMA) and PASW Statistics 18 and a meta-analysis was performed to obtain the measure of an overall effect (odds ratio, OR). A forest plot was used to report the results. A forest plot is made up of squares in which each square represents the sample size and the lines beside each square represent the 95% confidence interval for each study. A funnel plot was used for assessment of publication bias. The methods of handling data and statistical methods as fixed or random effects models were used for combining results of studies. The study of heterogeneity was made by I² statistical calculation. I² values of 25%, 50%, and 75% correspond to cut-of points for low, moderate, and high degrees of heterogeneity. If condition was homogeneity, fixed model was used and a heterogeneity condition was used random effects models. The level of significance used in the analysis was 5% ($\alpha=0.05$).

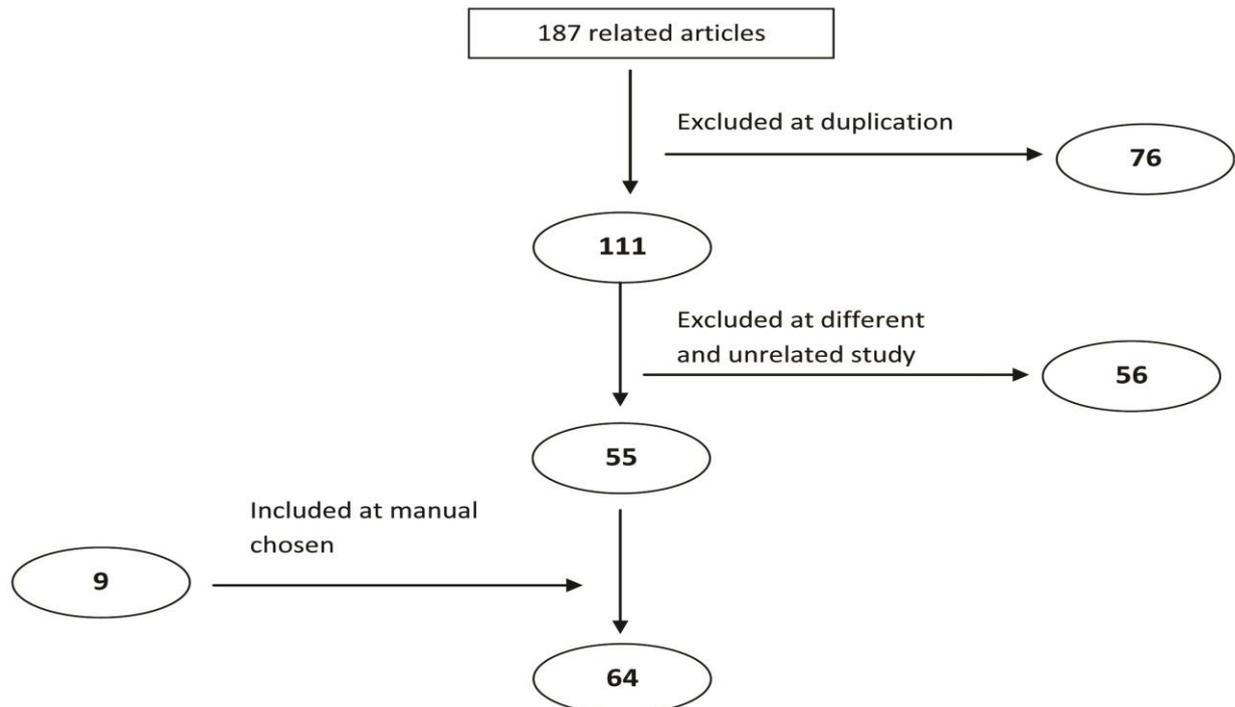


Figure 1. Summary of studies contributing to the Systematic Review

Table 1. Summary of performed process for searching strategy

| Phases |
|--|
| Phase 1 |
| Planning of search strategy |
| Electronic search from databases (Science Direct, ProQuest, Springer, Google Scholar, PubMed) |
| Selection of related articles based on titles |
| Phase 2 |
| Collection of articles with full text |
| Evaluation of quality articles by two appraisers |
| Exclusion of unrelated studies (related to adults, battery swallowing ,drug abuse, published articles before 1980) |
| Assessment of articles and referring disputes to the third appraiser |
| Phase 3 |
| Exclusion of unrelated studies based on the subject, Cohort studies, Case control studies, Clinical trial, Animal studies, Systematic review |
| Performance of manual research and inclusion of review articles references |
| Phase 4 |
| Extraction of article information and statistical analysis |

Results

A total of 187 studies were identified based on the exclusion and inclusion criteria. Out of them, 76 papers were excluded in Phase 2, and 56 articles in Phase 3. Further, nine manually selected articles were added in Phase 3, leading to the final sample of 64 articles from which data were extracted (Table 2).

From 64 (11,345 participants) articles that were included in our study, 52 articles were cross-sectional studies (81.5%), eight articles were case reports (12.5%), and four articles were case series (6%). Most of the studies were conducted in Turkey with 14 articles (21.8 %).

The sample of children comprised 4,632 boy (55.33%) and 3,756 girl (44.77%). With reference to distribution of gender, based on the results of different studies and the random effect model, we found that the frequency of caustic agent ingestion was more common in boys (42%, 95% CI: 0.29–0.57); however, this difference was not statistically significant. The mean age of the children with reported cases of ingestion was 2.78 (2.02) years (age range: 12 days–10 years).

The mean time of endoscopy after ingestion was 30 hours (range: 1–108 hours).

The most common caustic substance was alkaline, reported in 41.5% patients, followed by acid (30.7%), while most of the cases were exposed to household cleaning agents,

particularly bleaches and cleaners. With reference to industrial agents, the most abused agents were industrial detergents and soda.

Various factors were found to have an impact on the severity of the injuries presented. Most common were those related to the physical characteristics of agents, such as concentration, amount of ingested agent, type of agent, and interval between swallowing and referral to emergency department.

A majority of the patients were symptomatic at admission, and the most common symptoms included gastric, respiratory, and ENT-related symptoms. Vomiting, abdominal pain, dysphagia, respiratory distress, drooling, and burns of the oral cavity were the most frequently observed symptoms (Table 2).

The majority of the lesions observed in digestive, respiratory, and ENT tracts. The injuries of digestive included esophageal damage, nutritional problems, gastro-esophageal reflux, and gastric ulceration, respectively. The injuries of respiratory were aspiration pneumonia, laryngeal sore and mediastinitis. Skin sore, mouth sore, and sore throat were reported as lesions of ENT. Esophageal cancer and even death was also reported in ingested children. The summary of articles based on injuries and complications are shown in table 3.

Table 2. Classification of characteristics of agents, clinical findings, methods of diagnostic and therapeutic, and complications

| Subgroup |
|---|
| Type of ingested agents |
| Household chemicals |
| Industrial chemicals |
| Effective factors in presentation of clinical symptoms and complications |
| The demographic characteristics of the individual |
| The physical properties of agents |
| The physical properties of the individual |
| The manners of consume of agents |
| Clinical symptoms |
| Gastrointestinal problems |
| Respiratory problems |
| ENT problems |
| Cardiovascular problems |
| Neurological problems |
| Psychological problems |
| Techniques of diagnosis |
| Invasive |
| Non-invasive |
| Methods of therapeutics |
| Supportive therapies |
| Medical therapies |
| Surgical therapies |
| Complications |
| Gastrointestinal complications |
| Respiratory complications |
| Renal complications |
| Hepatic complications |
| Cardiovascular complications |

Table 3. The summary of articles based on injuries and complications

| Authors | Location | Injuries | Complications |
|--------------------------------------|-----------|---|----------------------------------|
| Mamede R. et al ¹ | Brazil | - | Gastrointestinal-death |
| Turner A. et al ² | England | Gastrointestinal- psychological | - |
| Lee HJ. et al ³ | Korea | Gastrointestinal- respiratory- psychological | - |
| Bicakci U. et al ⁴ | Turkey | Psychological | Gastrointestinal |
| Stiff G. et al ⁶ | Wales | Gastrointestinal- psychological | Respiratory-renal-cardiovascular |
| Manenti F. et al ⁷ | England | - | Gastrointestinal- respiratory |
| Sawalha AF. et al ⁸ | Palestine | Gastrointestinal- psychological – cardiovascular | - |
| Ekpe EE. et al ⁹ | Nigeria | - | Gastrointestinal-death |
| Arévalo-Silva C. et al ¹⁰ | - | Gastrointestinal- respiratory | Gastrointestinal |
| Temiz A. et al ¹⁵ | Turkey | Gastrointestinal- respiratory- psychological | Gastrointestinal- cardiovascular |
| Mamede RCM. et al ¹⁶ | Brazil | - | Gastrointestinal-death |
| Previtera C. et al ¹⁷ | Italy | Gastrointestinal- respiratory- psychological -ENT | Gastrointestinal |
| Casasnovas AB. et al ¹⁸ | Spain | Gastrointestinal- respiratory- psychological | - |
| Otçu S. et al ²¹ | Turkey | - | - |
| Doğan Y. et al ²² | Turkey | - | Gastrointestinal |
| Ciftci AO. et al ²³ | Turkey | Psychological | - |
| Pearn J. et al ²⁴ | Australia | ENT- psychological | - |
| Broto J. et al ²⁵ | Spain | - | Gastrointestinal |

Table 3. The summary of articles based on injuries and complications (continued)

| Authors | Location | Injuries | Complications |
|----------------------------------|--------------|--|------------------------------------|
| Ein S H. et al ²⁶ | Canada | - | Respiratory-death |
| Ryan F. et al ²⁷ | England | Gastrointestinal | - |
| Ferguson MK. et al ²⁸ | America | Gastrointestinal- respiratory- psychological | Gastrointestinal |
| Riffat F. et al ²⁹ | Australia | Gastrointestinal- psychological | Gastrointestinal |
| Contini S. et al ³⁰ | Italy | Gastrointestinal- respiratory- psychological -ENT | Gastrointestinal |
| Youn BJ. et al ³¹ | Korea | Gastrointestinal- psychological | Gastrointestinal- respiratory |
| Arici M. et al ³² | Turkey | Gastrointestinal- psychological | - |
| Melek M. et al ³³ | Turkey | Gastrointestinal- respiratory- psychological | Gastrointestinal |
| Bychkova OV. et al ³⁴ | Belarus | Psychological | Gastrointestinal-respiratory |
| Reith DM. et al ³⁵ | Australia | - | Cardiovascular |
| Kane TD. et al ³⁶ | America | Gastrointestinal | Gastrointestinal- respiratory |
| Pintus C. et al ³⁷ | - | - | - |
| Huang YC. et al ³⁸ | Taiwan | Gastrointestinal | Gastrointestinal |
| Babl FE. et al ³⁹ | America | Gastrointestinal- respiratory- psychological | - |
| Betalli P. et al ⁴⁰ | Italy | Gastrointestinal- respiratory- psychological - cardiovascular- ENT | Gastrointestinal |
| Thirlwall A. et al ⁴¹ | England | Gastrointestinal- psychological | Gastrointestinal |
| Thomas MO. et al ⁴² | Nigeria | Gastrointestinal | Gastrointestinal |
| Karnak I. et al ⁴³ | Turkey | - | Gastrointestinal |
| Turna C. et al ⁴⁴ | Turkey | Gastrointestinal- respiratory- psychological | Gastrointestinal- respiratory |
| Janoušek P. et al ⁴⁵ | Czech | Gastrointestinal | Gastrointestinal |
| Saetti R. et al ⁴⁶ | Italy | - | Gastrointestinal |
| Stone MM. et al ⁴⁷ | America | - | Gastrointestinal- respiratory |
| Gerzic ZB. et al ⁴⁸ | Yugoslavia | Psychological | - |
| Ceylan H. et al ⁴⁹ | Turkey | Gastrointestinal- respiratory- psychological | Gastrointestinal |
| Kukkady A. et al ⁵⁰ | New Zealand | Gastrointestinal | Gastrointestinal |
| Chen TY. et al ⁵¹ | Taiwan | Gastrointestinal-respiratory-psychological- cardiovascular | Gastrointestinal-death |
| Shukla RM. et al ⁵² | India | Psychological | - |
| Turner A. et al ⁵³ | Australia | - | - |
| Ozcan C. et al ⁵⁴ | Turkey | - | Gastrointestinal |
| Rigo GP. et al ⁵⁵ | Italy | - | Gastrointestinal-death |
| Brown RA. et al ⁵⁶ | South Africa | Psychological | Gastrointestinal |
| Baskın D. et al ⁵⁷ | Turkey | Gastrointestinal- psychological | Gastrointestinal |
| Brun JG. et al ⁵⁸ | - | - | - |
| Tiryaki T. et al ⁵⁹ | Turkey | - | Gastrointestinal |
| Gupta SK. et al ⁶⁰ | India | Gastrointestinal-respiratory- psychological | - |
| Uhlen S. et al ⁶¹ | America | Psychological | Gastrointestinal |
| Heran MK. et al ⁶² | Canada | Gastrointestinal | Gastrointestinal |
| Rosseneu S. et al ⁶³ | England | - | Gastrointestinal |
| Lin YC. et al ⁶⁴ | Taiwan | Gastrointestinal | Gastrointestinal |
| Atabek C. et al ⁶⁵ | Turkey | - | Gastrointestinal |
| Wiseman HM. et al ⁶⁶ | England | Gastrointestinal- respiratory- psychological | Hepatic – renal |
| Mehreghan F. et al ⁶⁷ | Iran | Respiratory- psychological- neurological | Gastrointestinal-respiratory-death |
| Azadeghan M. et al ⁶⁸ | Iran | Gastrointestinal- respiratory- psychological | - |
| Rafeey M. et al ⁶⁹ | Iran | Gastrointestinal- psychological | Gastrointestinal-death |
| Talebyan A. et al ⁷⁰ | Iran | Respiratory- psychological- neurological | - |
| Osar SH. et al ⁷¹ | Iran | Respiratory- psychological- neurological- gastrointestinal-ENT- cardiovascular | - |

Our review revealed that physical examination and invasive techniques were carried out for detection and evaluation of digestive tract lesions. Endoscopy was frequently performed in addition to other diagnostic methods, such as esophagoscopy and barium swallows.

Therapeutic protocols included medical, surgical, and conservative treatments, respectively. Serum therapy, antibiotics, systemic steroids, Anti-acid, H₂ blockers, protein pump inhibitors, and topical injection of Mitomycin and steroid were used. The most common surgical methods included esophageal dilatation and esophageal

replacement. Implantation of a stent and catheter in the esophagus were also mentioned in some of the articles. On selecting for the meta-analysis the 64 articles that showed the caustic ingestion in children, the Forest plot stated OR=0.53 (Figure 2) with a 95% confidence interval (95% CI) of 0.49-0.57 (P=0.08) for boys and OR=0.38 (Figure. 2) with a 95% confidence interval (95% CI) of 0.35-0.42 (P<0.001) for girls. Therefore, the caustic ingestion was more common in boys compared to girls. The studies were non-homogeneous (I²=83.68% and P<0.001 for boys & I²=82.44% and P<0.001 for girls), so for estimate risk was used from random results.

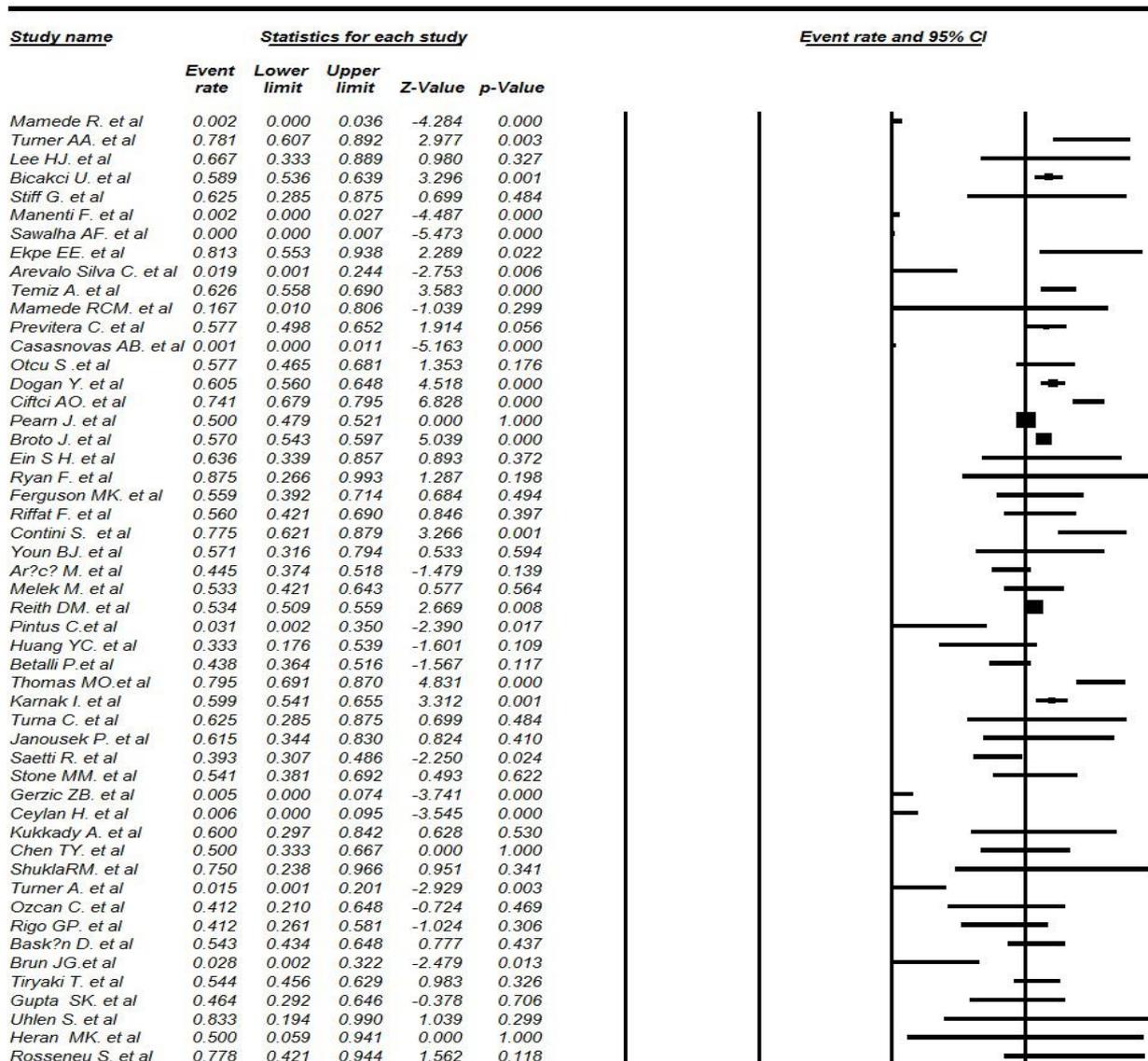


Figure 2. Meta-analysis for boys and girls

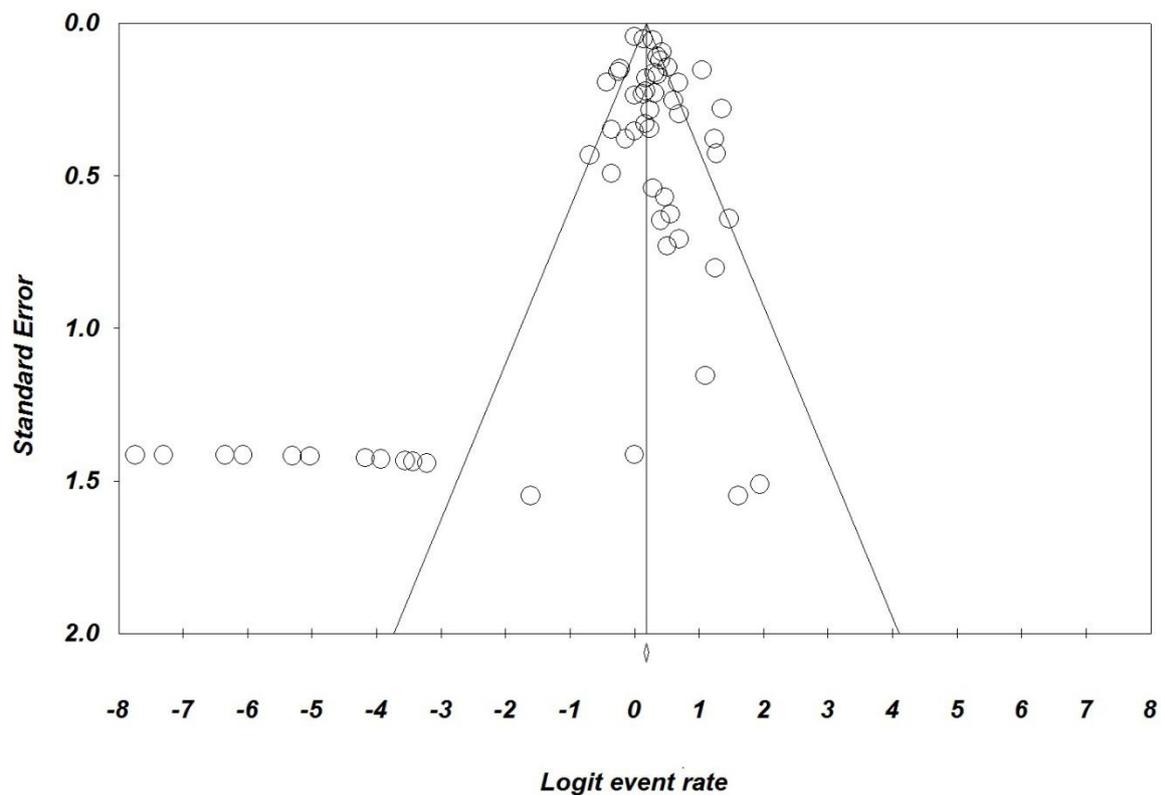


Figure 3. Funnel plot of standard error by logit event rate for boys and girls

The extracted data are shown in the funnel plot to evaluate the publication bias for sample size and effect size (Figure 3). Regarding the funnel plot view, it may be noted that the publication bias in the process of search and selection in the present study was at an acceptable level (Table 1).

Discussion

The goal of this systematic review was to evaluate previous literature and examine the age distribution, sex ratio, and the types of ingested agents, symptoms and signs, management, and the impact of chemical factors on the complications caused by the ingestion of caustic agents in children because of highlighting on primary preventive programs. The widespread use, easy availability, low costs of cleaners and detergents especially in Asia¹⁷ as well as other products have led to an increase in the

occurrence of swallowing of agents among children.

In term of demographic characteristics, we found that the group at the highest risk for accidental caustic ingestion comprised children of preschool ages (mean age = 1.74 (3.38) years), and mostly boys were involved in such incidents. In a study by Seluck Otcu in Turkey, 58% of the children who ingested caustic substances were boys, and 42% were girls, with a mean age of 3.6 (2.8) years.²¹ Other related studies had similar results.^{22,23,72} Children, especially boys, have well-developed skills and are curious to examine substances and drink them. However, they lack the knowledge of the portability of substances. This implies that boys in preschool stage (3–4 years) need more attention and caring by parents to avoid such ingestion incidents. Moreover, parents' behaviors are affected further by culture.^{5,23} It is

recommended to consider these points by families:

- The large amounts of detergent must not be kept at the home, especially at kitchen.
- Chemical substances should be placed on the locked cabinet and the upper shelves and were immediately put in its place after utilization.
- Chemical materials should be kept in the labeled containers with tight door.
- Chemicals substances should not be stored in food containers.
- When a drug is given as a medicine, it not be mentioned as candy.

The phone number of emergency department and poisoning control center should be recorded in notebook at home.^{5-9,24,25} In this present review, we found that most accidents were due to alkaline agents, such as bleach products, oven cleaners, and soda.

These products are often used to clean the house; however, they can cause various types of poisoning.⁸ In a study conducted in Australia, 76% of the accidents were reported to have occurred at home, where 74% were caused by alkaline, 6% by acidic agents, and 20% were caused by contamination with other agents.⁷²

Parents should avoid storing such substances in everyday, unmarked drinking bottles, especially in containers that are known to hold edible substances. It was reported in Iran and Turkey that in most cases such caustic agents had been stored in accessible places in the house and in containers without labels.^{1,15,26} Most of the studies emphasized the impact of educating parents by multimedia for raising their awareness and self-efficacy in their care of children.^{26,73}

The present study revealed that the most common signs and symptoms of caustic ingestion were related to digestive, respiratory, and ENT tracts. In a study conducted in Turkey, it was found that gastrointestinal symptoms were predominant during admission. In addition, respiratory symptoms were observed in 13% of the cases.⁷²

In order to detect lesions and evaluate the severity of the damage, physical examination, non-invasive techniques, and invasive technique especially endoscopy was used for nearly all patients. Ferguson et al., believed that the first step in the treatment of these patients is physical examination.²⁸ In this present review, the mean of initiating time of the endoscopic examination was 30 hours. In different studies, endoscopy was offered within 24-48 hours.^{18,72} Managing and following of patients result in the early diagnosis of complications and the application of continues therapeutic recommendations and health care.²⁹ The increasing of parent awareness toward preliminary canings after agent swallowing and the handling of health and caring centers on proper admission, management and care could be helpful about this episode.³⁰⁻³²

Esophageal damage, gastro-esophageal reflux, and gastric ulceration, respectively were common injuries of corrosive substance ingestion in children. The injuries of respiratory system were aspiration pneumonia and laryngeal sore. Malignant transformation was reported during long-term follow-ups. In the study conducted in Turkey, Esophageal stricture observed in 24.2% (16 patients) by endoscopy.⁷⁴ In another study in South Korea, esophageal stricture was identified as the most common long-term complication.⁷² Similarly, mortality and esophageal cancer were observed in a study conducted in Brazil.¹⁶ Thus, it is clear that although ingestion of caustic substances is relatively rare, its effects are debilitating.²⁷

In the present study, we found those medical therapies such as oral antibiotics, systemic steroids, and H2 blockers; surgical therapy, such as esophageal dilatation; and conservative treatments were used. These findings were similar to other studies.^{18,30,33,34,75,76}

Assessment of involvement of other organs and recovery through massage could help to prevent secondary problems. In our study, medical therapies such as oral antibiotics, systemic steroids and H₂ blockers, surgical

therapies such as esophageal dilatation and conservative treatments were utilized to limit the severity of inflammation and infection.⁹

Rajinder *et al.*, reported similar results in New York.³⁶ Although the benefit of each treatment have not been determined by investigators, therapeutic methods should be able to develop as the child growth.⁹

The major advantage of the present study was the use of an appropriate number of authentic studies. This advantage, along with the large sample size across all the selected studies, enabled us to use the funnel plot to assess publication bias. However, a limitation in this study was the poor accessibility of European and American papers because of problem sanctions on Iran. Finally, we recommend that more case control or clinical trial studies should be performed to provide guidelines and protocols.

Conclusion

This study implies the role of families, manufacturers, media, health care systems, and government in these accidents. Appropriate storage and usage of these hazardous substances is strongly recommended for parents. Producing materials with formulation and packaging agents in factories are essential factors. Moreover, the media and educational programs can raise public awareness. Thus, the primary prevention and reduction of undesirable health effects of accidental ingestion of caustic substances is practical and simple.

Also, we recommend that continues management and caring health programs should be applied because of the effects range from an asymptomatic state to intractable complications. With reference to treatment strategies, thus, comprehensive and continues treatment should be carried out in all cases of caustic ingestion; consist of medical therapies such as oral antibiotics, systemic steroids and H2 blockers, surgical therapies such as esophageal dilatation and conservative

treatments were utilized to limit the severity of inflammation and infection.

Acknowledgments

We would like to thank liver & gastrointestinal disease research center.

Ethical issues

None to be declared.

Conflict of interest

The authors declare no conflict of interest in this study.

References

1. Mamede R, De Mello Filho F. Treatment of caustic ingestion: an analysis of 239 cases. *Diseases of the Esophagus* 2002;15 (3):210-3. doi: [10.1046/j.1442-2050.2002.00263.x](https://doi.org/10.1046/j.1442-2050.2002.00263.x)
2. A Turner, Robinson P. Respiratory and gastrointestinal complications of caustic ingestion in children. *Emergency Medicine Journal* 2005; 22 (5): 359-61. doi:[10.1136/emj.2004.015610](https://doi.org/10.1136/emj.2004.015610)
3. Lee HJ, Lee JH, Seo JM, Lee SK, Choe YH. A single center experience of self-bougienage on stricture recurrence after surgery for corrosive esophageal strictures in children. *Yonsei Med J* 2010; 51 (2): 202-5. doi:[10.3349/ymj.2010.51.2.202](https://doi.org/10.3349/ymj.2010.51.2.202)
4. Bicakci U, Tander B, Deveci G, Rizalar R, Ariturk E, Bernay F. Minimally invasive management of children with caustic ingestion: less pain for patients. *Pediatric Surgery International* 2010; 26 (3): 251-5. doi:[10.1007/s00383-009-2525-5](https://doi.org/10.1007/s00383-009-2525-5)
5. Hockenberry MJ, Wilson D. *Wong's Nursing Care of Infants and Children Multimedia Enhanced Version*. 9th ed. United States: Mosby. 2013.
6. Stiff G, Alwafi A, Rees B, Lari J. Corrosive injuries of the oesophagus and stomach: experience in management at a regional paediatric centre. *Ann R Coll Surg Engl* 1996;78 (2): 119-23.

7. Manenti F. What is the utility of selected clinical and endoscopic parameters in predicting the risk of death after caustic ingestion? *Endoscopy* 2002; 34 (4): 304-10. doi: [10.1055/s-2002-23633](https://doi.org/10.1055/s-2002-23633)
8. Sawalha AF. Storage and utilization patterns of cleaning products in the home: toxicity implications. *Accident Analysis & Prevention* 2007; 39 (6):1186-91. doi:[10.1016/j.aap.2007.03.007](https://doi.org/10.1016/j.aap.2007.03.007)
9. Ekpe E, Ette V. Morbidity and mortality of caustic ingestion in rural children: experience in a new cardiothoracic surgery unit in Nigeria. *ISRN Pediatr* 2012; 2012 (2012): 4. doi:[10.5402/2012/210632](https://doi.org/10.5402/2012/210632)
10. Arévalo-Silva C, Eliashar R, Wohlgelernter J, Elidan J, Gross M. Ingestion of caustic substances: a 15-year experience. *The Laryngoscope* 2006; 116 (8): 1422-6. doi: [10.1097/01.mlg.0000225376.83670.4d](https://doi.org/10.1097/01.mlg.0000225376.83670.4d)
11. Amini Ranjbar H, Azadegan M. Clinical signs and endoscopic findings of the upper gastro intestinal tract in patients admitted at toxication department of Loghman Hakim hospital in Tehran with the history of caustic substances ingestion (acid or alkaline) in 2007. *Pajoohandeh* 2009; 14 (3): 123-8. (Persian)
12. Mehregan F, Yavari P, Nourbakhsh M, Kheyri M. The study of clinical trend and effects of caustic ingestion based on endoscopy of children referring to Loghman Hakim hospital. *Iranian Journal of Pediatrics* 2004; 14 (2): 125-31.
13. Adib-Hajbaghery M, Maghaminejad F, Abbasi A. The role of continuous care in reducing readmission for patients with heart failure. *J Car Sci* 2013; 2 (4): 255-67. doi: [10.5681/jcs.2013.031](https://doi.org/10.5681/jcs.2013.031)
14. Salimi S, Azimpour A. Determinants of Nurses' Caring Behaviors (DNCB): Preliminary Validation of a Scale. *J car Sci* 2013; 2 (4): 269.
15. Temiz A, Oguzkurt P, Ezer SS, Ince E, Hicsonmez A. Predictability of outcome of caustic ingestion by esophagogastroduodenoscopy in children. *World J Gastroenterol* 2012; 18 (10): 1098-1103. doi: [10.3748/wjg.v18.i10.1098](https://doi.org/10.3748/wjg.v18.i10.1098)
16. Mamede RCM, Mello Filho FVd. Ingestion of caustic substances and its complications. *Sao Paulo Med J* 2001;119 (1): 10-5. doi:[10.1590/S1516-31802001000100004](https://doi.org/10.1590/S1516-31802001000100004)
17. Previtera C, Giusti F, Guglielmi M. Predictive value of visible lesions (cheeks, lips, oropharynx) in suspected caustic ingestion: may endoscopy reasonably be omitted in completely negative pediatric patients? *Pediatric Emergency Care* 1990; 6 (3): 176-8.
18. Casanovas AB, Martinez EE, Cives RV, Jeremias AV, Sierra RT, Cadranel S. A retrospective analysis of ingestion of caustic substances by children. Ten-year statistics in Galicia. *Eur J Pediatr* 1997; 156 (5): 410-4. doi:[10.1007/s004310050627](https://doi.org/10.1007/s004310050627)
19. Rafeey M, Ghojzadeh M, Mehdizadeh A, Hazrati H, Vahedi L. Intercontinental comparison of caustic ingestion in children. *Korean J Pediatr* 2015; 58 (12): 491-500. doi:[10.3345/kjp.2015.58.12.491](https://doi.org/10.3345/kjp.2015.58.12.491)
20. Atabek C, Surer I, Demirbag S, Caliskan B, Ozturk H, Cetinkursun S. Increasing tendency in caustic esophageal burns and long-term polytetraflourethylene stenting in severe cases: 10 years' experience. *Journal of Pediatric Surgery* 2007; 42 (4): 636-40. doi: [10.1016/j.jpedsurg.2006.12.012](https://doi.org/10.1016/j.jpedsurg.2006.12.012)
21. Otçu S, Karnak I, Tanyel FC, Senocak ME, Buyukpamukcu N. Biochemical indicators of caustic ingestion and/or accompanying esophageal injury in children. *Turk J Pediatr* 2003; 45 (1): 21-5.
22. Doğan Y, Erkan T, Çokuğraş FÇ, Kutlu T. Caustic gastroesophageal lesions in childhood: an analysis of 473 cases. *Clinical pediatrics*. 2006; 45 (5): 435-8. doi: [10.1177/0009922806289618](https://doi.org/10.1177/0009922806289618)

23. Ciftci A, Şenocak M, Büyükpamukçu N, Hiçsönmez A. Gastric outlet obstruction due to corrosive ingestion: incidence and outcome. *Pediatric Surgery International* 1999; 15 (2): 88-91. doi:[10.1007/s00383-004-1153-3](https://doi.org/10.1007/s00383-004-1153-3)
24. Pearn J, Nixon J, Ansford A, Corcoran A. Accidental poisoning in childhood: five year urban population study with 15 year analysis of fatality. *Br Med J (Clin Res Ed)* 1984; 288 (6410): 44-6. doi: [10.1136/bmj.288.6410.44](https://doi.org/10.1136/bmj.288.6410.44)
25. Broto J, Asensio M, Jorro CS, Marhuenda C, Vernet JG, Acosta D, et al. Conservative treatment of caustic esophageal injuries in children: 20 years of experience. *Pediatric Surgery International* 1999; 15 (5-6): 323-5. doi:[10.1007/s003830050591](https://doi.org/10.1007/s003830050591)
26. Ein SH. Gastric tubes in children with caustic esophageal injury: a 32-year review. *Journal of Pediatric Surgery* 1998; 33 (9): 1363-5. doi: [10.1016/S0022-3468\(98\)90008-2](https://doi.org/10.1016/S0022-3468(98)90008-2)
27. Ryan F, Witherow H, Mirza J, Ayliffe P. The oral implications of caustic soda ingestion in children. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006; 101 (1): 29-34. doi:[10.1016/j.tripleo.2005.04.025](https://doi.org/10.1016/j.tripleo.2005.04.025)
28. Ferguson MK, Migliore M, Staszak VM, Little AG. Early evaluation and therapy for caustic esophageal injury. *The American Journal of Surgery* 1989; 157 (1): 116-20. doi: [10.1016/0002-9610\(89\)90430-3](https://doi.org/10.1016/0002-9610(89)90430-3)
29. Riffat F, Cheng A. Pediatric caustic ingestion: 50 consecutive cases and a review of the literature. *Diseases of the Esophagus* 2009; 22 (1): 89-94. doi: [10.1111/j.1442-2050.2008.00867.x](https://doi.org/10.1111/j.1442-2050.2008.00867.x)
30. Contini S, Tesfaye M, Picone P, Pacchione D, Kupperts B, Zambianchi C, et al. Corrosive esophageal injuries in children: a short lived experience in Sierra Leone. *Int J Pediatr Otorhinolaryngol* 2007; 71 (10): 1597-604. doi: [10.1016/j.ijporl.2007.07.007](https://doi.org/10.1016/j.ijporl.2007.07.007)
31. Youn BJ, Kim WS, Cheon J-E, Kim W-Y, Shin S-M, Kim I-O, et al. Balloon dilatation for corrosive esophageal strictures in children: radiologic and clinical outcomes. *Korean J Pediatr* 2010; 11 (2): 203-10. doi:[10.3348/kjr.2010.11.2.203](https://doi.org/10.3348/kjr.2010.11.2.203)
32. Arıcı M, Ozdemir D, Oray N, Buyukdeligoz M, Tuncok Y, Kalkan S. Evaluation of caustics and household detergents exposures in an emergency service. *Human & experimental toxicology*. 2012; 31 (6): 533-8. doi:[10.1177/0960327111412803](https://doi.org/10.1177/0960327111412803)
33. Melek M, Edirne Y, Çobanoğlu U, Ceylan A, Can M. An analysis of corrosive substance ingestion of children in eastern Turkey. *East J Med* 2008; 13 (1-2): 1-6.
34. Bychkova O.V, Lazyuk II, Averin V. Bio-degradable stents—new approach to the treatment of caustic stenoses in children. *Folia Gastroenterol Hepatol* 2009; 7 (1): 30-4.
35. Reith D, Pitt W, Hockey R. Childhood poisoning in Queensland: an analysis of presentation and admission rates. *Journal of Paediatrics and Child Health* 2001; 37 (5): 446-50. doi: [10.1046/j.1440-1754.2001.00666.x](https://doi.org/10.1046/j.1440-1754.2001.00666.x)
36. Kane TD, Nwomeh BC, Nadler EP. Thoracoscopic-assisted esophagectomy and laparoscopic gastric pull-up for lye injury. *J SLS* 2007; 11 (4): 474-80.
37. Pintus C, Manzoni C, Nappo S, Perrelli L. Caustic ingestion in childhood: current treatment possibilities and their complications. *Pediatric Surgery International* 1993; 8 (2): 109-12. doi:[10.1007/BF00184211](https://doi.org/10.1007/BF00184211)
38. Huang YC, Ni Y-H, Lai H-S, Chang M-H. Corrosive esophagitis in children. *Pediatric Surgery International* 2004; 20 (3): 207-10.
39. Babl FE, Kharsch S, Woolf A. Airway edema following household bleachingestion. *Am J Emerg Med* 1998; 16 (5): 514–16. doi: [10.1016/S0735-6757\(98\)90006-7](https://doi.org/10.1016/S0735-6757(98)90006-7)

40. Betalli P, Falchetti D, Giuliani S, Pane A, Dall'Oglio L, Luigi de' Angelis G, et al. Caustic ingestion in children: is endoscopy always indicated? The results of an Italian multicenter observational study. *Gastrointestinal Endoscopy* 2008; 68 (3): 434–39. doi: [10.1016/j.gie.2008.02.016](https://doi.org/10.1016/j.gie.2008.02.016)
41. Thirlwall A, Friedman N, Leighton S, Saunders M, Jacob A, Kangesu L. Caustic soda ingestion—a case presentation and review of the literature. *Int J Pediatr Otorhinolaryngol* 2001; 59 (2): 129–35. doi: [10.1016/s0165-5876\(01\)00461-x](https://doi.org/10.1016/s0165-5876(01)00461-x)
42. Thomas MO, Ogunleye E O, Somefun O. Chemical injuries of the esophagus: aetiopathological issues in Nigeria. *J Cardiothorac Surg* 2009; 4: 56. doi: [10.1186/1749-8090-4-56](https://doi.org/10.1186/1749-8090-4-56)
43. Karnak I, Tanyel F.C, Buyukpamukcu N, Hicsonmez A. Combined use of steroid, antibiotics and early bougienage against stricture formation following caustic esophageal burns. *J Cardiovasc Surg* 1999; 40 (2): 307–10.
44. Turna C, Ozkan U, Ozokutan BH, Ozdemir M, Kucukaydin M. Corrosive injuries of the esophagus in newborns. *Pediatr Surg Int* 2000; 16 (7): 483–4.
45. Janoušek P, Jurovčík M, Grabec P, Kabelka Z. Corrosive oesophagitis in children following ingestion of sodium hydroxide granules—A case report. *Int J Pediatr Otorhinolaryngol* 2005; 69 (10): 1429–32. doi: [10.1016/j.ijporl.2005.03.032](https://doi.org/10.1016/j.ijporl.2005.03.032)
46. Saetti R, Silvestrini M, Cutrone C, Barion U, Mirri L, Narne S. Endoscopic treatment of upper airway and digestive tract lesions caused by caustic agents. *ANN Otol Rhinol Laryngol* 2003; 112 (1): 29–36. doi: [10.1177/000348940311200107](https://doi.org/10.1177/000348940311200107)
47. Stone MM, E W Fonkalsrud, G H Mahour, J J Weitzman, H Takiff. Esophageal replacement with colon interposition in children. *Ann Surg* 1986; 203 (4): 346–51.
48. Gerzic ZB, Knezevic J B, Milicevic M N, Jovanovic B K. Esophagoplasty in the management of post corrosive strictures of the esophagus. *Ann Surg* 1990; 211 (3): 329–36.
49. Ceylan H, Ozokutan B H, Gunduz F, Gozen A. Gastric perforation after corrosive ingestion. *Pediatr Surg Int* 2011; 27: 649–53. doi: [10.1007/s00383-010-2739-6](https://doi.org/10.1007/s00383-010-2739-6)
50. Kukkady A, Pease PWB. Long-term dilatation of caustic strictures of the esophagus. *Pediatr Surg Int* 2002; 18 (5): 486–90. doi: [10.1007/s00383-002-0798-z](https://doi.org/10.1007/s00383-002-0798-z)
51. Chen TY, Ko SF, Chuang JH, Kuo HW, Tiao MM. Predictors of esophageal stricture in children with unintentional ingestion of caustic agents. *Chang Gung Med J* 2003; 26 (4): 233–9.
52. Shukla RM, Mukhopadhyay M, Tripathy BB, Mandal KC, Mukhopadhyay B. Pyloric and antral strictures following corrosive acid ingestion: A report of four cases. *J Indian Assoc Pediatr Surg*. 2010; 15 (3): 108–09. doi: [10.4103/0971-9261.71749](https://doi.org/10.4103/0971-9261.71749)
53. Turner A, De Jong AL, Macdonald R, Ein S, Forte V. Corrosive esophagitis in children: a 30-year review. *Int J Pediatr Otorhinolaryngol* 2001; 57 (3): 203–11. doi: [10.1016/S0165-5876\(00\)00440-7](https://doi.org/10.1016/S0165-5876(00)00440-7)
54. Özcan C, Erinc R, Dirlik A, Mutaf O. Scintigraphy in the detection of gastro-oesophageal reflux in children with caustic oesophageal burns: a comparative study with radiography and 24-h PH monitoring. *Pediatric Radiology* 2001; 31 (10): 737–41.
55. Rigo GP, Camellini L, Azzolini F, Guazzetti S, Bedogni G, Merighi A, Bellis L, Scarcelli A, Manenti F. What is the utility of selected clinical and endoscopic parameters in predicting the risk of death after caustic ingestion?. *Endoscopy* 2002; 34 (4): 304–10. doi: [10.1055/s-2002-23633](https://doi.org/10.1055/s-2002-23633)
56. Brown RA, Millar AJW, Numanoglu A. Y-V advancement antroplasty for

- corrosive antral strictures. *Pediatric Surgery International* 2002; 18 (4): 252-54. doi: [10.1007/s003830100664](https://doi.org/10.1007/s003830100664)
57. Baskin D, Urganci N, Abbasoğlu L, Alkim C, Yalçın M, Karadağ C, Sever N. A standardised protocol for the acute management of corrosive ingestion in children. *Pediatric Surgical International* 2004; 20 (11): 824-8. doi: [10.1007/s00383-004-1294-4](https://doi.org/10.1007/s00383-004-1294-4)
58. Burn JG, Celerier M, Koska F, Dubost C. Blunt thoracic oesophageal stripping: an emergency procedure for caustic ingestion. *British Journal of Surgery* 1984; 71 (9): 698-700. doi: [10.1002/bjs.1800710918](https://doi.org/10.1002/bjs.1800710918)
59. Tiryaki T, Livanelioğlu Z, Atayurt H. Early bougienage for relief of stricture formation following caustic esophageal burns. *Pediatr Surg Int* 2005; 21 (2): 78-80. doi: [10.1007/s00383-004-1331-3](https://doi.org/10.1007/s00383-004-1331-3)
60. Gupta SK, Croffie JM, Fitzgerald JF. Is Esophagogastroduodenoscopy Necessary in all Caustic Ingestions? *Journal of Pediatric Gastroenterology and Nutrition* 2001; 32 (1): 50-3.
61. Uhlen S, Fayoux P, Vachin F, Guimber D, Gottrand D, Turck D, Michaud L, Mitomycin C. An alternative conservative treatment for refractory esophageal stricture in children? *Endoscopy* 2006; 38 (4): 404-7.
62. Heran MKS, Baird R, Blair GK, Skarsgard ED. Topical mitomycin-c for recalcitrant esophageal strictures: a novel endoscopic /fluoroscopic technique for safe endoluminal delivery. *Journal of Pediatric Surgery* 2008; 43 (5): 815-18. doi: [10.1016/j.jpedsurg.2007.12.017](https://doi.org/10.1016/j.jpedsurg.2007.12.017)
63. Rosseneu S, Afzal N, Yerushalmi B, Ibarguen-Secchia E, Lewindon P, Cameron D, et al. Topical application of mitomycin c in esophageal strictures. *J Pediatr Gastroenterol Nutr* 2007; 44 (3): 336-41. doi: [10.1097/MPG.0b013e31802c6e45](https://doi.org/10.1097/MPG.0b013e31802c6e45)
64. Lin YC, Ma JY. Severe esophageal burn following chloral hydrate overdose in an infant. *J Formos Med Assoc* 2006; 105 (3): 235-7. doi: [10.1016/S0929-6646\(09\)60311-9](https://doi.org/10.1016/S0929-6646(09)60311-9)
65. Atabek C, Surer I, Demirbag S, Caliskan B, Ozturk H, Cetinkursun S. Increasing tendency in caustic esophageal burns and long-term polytetrafluorethylene stenting in severe cases: 10 years' experience. *Journal of Pediatric Surgery* 2007; 42 (4): 636-40.
66. Wiseman HM, Turner W ML, Volans G N. Acute poisoning due to Wrights Vaporizing fluid. *Postgraduate Medical Journal* 1980; 56: 166-168.
67. Mehregan F, Yavari P, Nourbakhsh K, Kheyri M. The study of clinical trend and effects of caustic ingestion based on endoscopy of children referring to Loghman Hakim hospital. *Iranian Journal of Pediatrics* 2004; 14 (2): 125-31. (Persian)
68. Azadeghan M, Amini Ranjbar H. The study of clinical manifestation and laboratory findings and endoscopy Upper gastrointestinal tract in patients with a history of ingestion of chemicals Toxicology section Loghman hospital in 2007. *Pajoohandeh* 2009; 14 (3): 123-28. (Persian)
69. Rafeey M, Shoaran M. Clinical characteristics and complications in oral caustic ingestion in children. *Pak J Biol Sci* 2008; 11 (19): 2351-5. doi: [10.3923/pjbs.2008.2351.2355](https://doi.org/10.3923/pjbs.2008.2351.2355)
70. Vazirianzadeh B, Farhadpour F, Hosseinzadeh M, Zarean M, Moravvej SA. An epidemiological and clinical study on scorpionism in hospitalized children in khuzestan, Iran. *Journal of Arthropod-Borne Diseases* 2012; 6 (1): 62-9.
71. Assar S, Hatemi S, Lak E. Acute poisoning in children admitted to Ahwaz Abuzar and Golestan hospitals 2001-2004. *Jundishapur Scientific Medical Journal* 2008; 7 (1): 121-27. (Persian)
72. Huang Y-C, Ni Y-H, Lai H-S, Chang M-H. Corrosive esophagitis in children.

- Pediatric Surgery International 2004; 20 (3): 207-10. doi:[10.1007/s00383-004-1153-3](https://doi.org/10.1007/s00383-004-1153-3)
73. Zarei AR, Jahanpour F, Alhani F, Razazan N, Ostovar A. The impact of multimedia education on knowledge and self-efficacy among parents of children with asthma: a randomized clinical trial. *J Car Sci* 2014; 3 (3): 185-92. doi: [10.5681/jcs.2014.020](https://doi.org/10.5681/jcs.2014.020).
74. Özcan Z, Özcan C, Erin R, Dirlik A, Mutaf O. Scintigraphy in the detection of gastro-oesophageal reflux in children with caustic oesophageal burns: a comparative study with radiography and 24-h PH monitoring. *Pediatric radiology* 2001; 31(10): 737-41. doi:[10.1007/s002470100518](https://doi.org/10.1007/s002470100518)
75. Anderson KD, Rouse TM, Randolph JG. A controlled trial of corticosteroids in children with corrosive injury of the esophagus. *The New England Journal of Medicine* 1990; 323 (10): 637-40. doi: [10.1056/NEJM199009063231004](https://doi.org/10.1056/NEJM199009063231004)
76. Gandhi RP, Cooper A, Barlow BA. Successful management of esophageal strictures without resection or replacement. *Journal of Pediatric Surgery* 1989; 24 (8): 745-50. doi: [10.1016/s0022-3468\(89\)80529-9](https://doi.org/10.1016/s0022-3468(89)80529-9)