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Review article

ACUTE POISONINGS WITH CORROSIVE SUBSTANCES – NEW FINDINGS AND REVIEW OF OUR FIVE-YEAR MATERIAL

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Abstract

Ingestion of corrosive chemical substances remains a serious problem in modern clinical toxicology due to its high mortality rate in the acute phase and the risk of serious, long-term complications during the chronic phase.

Findings in this study are based on a five-year material (2017-2021), retrospectively collected from patients' records at the University Clinic for Toxicology and Urgent Internal Medicine in Skopje, Macedonia. It is a review of our clinical experience, discussion on the results of articles found in the Pub Med database and data citied in various articles related to management of acute corrosive poisonings.

This type of poisonings happens after an accidental or aware contact with corrosive substances, usually in suicide attempts. Mainly they happen after ingestion of corrosive chemicals, but often we witness injuries of respiratory organs as a result of inhalation of corrosive fumes, or dermal burns, after direct contact with the skin. There are various types of corrosive chemicals, but the majority of cases report contact with acids.

In the diagnosis of this type of intoxications, we use upper endoscopy as a gold standard for quick and proper diagnosis. Nowadays, early computerized tomography is also a recommended procedure for an early evaluation and intervention.

Treatment is based on the clinical condition of patients and it mainly consists of intravenous fluids, antacids, antibiotics, sedatives and protocols for artificial nutrition.

Keywords: corrosive intoxications, endoscopy, esophageal strictures

Introduction

Acute corrosive poisonings are intoxications that can still be seen in the clinical practice and they happen after a contact with chemical substances that are used in everyday life, mostly in households. They remain a serious medical and social issue because of the high incidence, suicidal intentions for ingestion, and risk of an unfavorable outcome or severe disability[1,2]. Therefore, health authorities of many countries exert serious efforts and incorporate numerous mechanisms in specialized education of the mass population. The number of

poisonings is still very high; patients develop serious symptomatology, examinations are numerous, treatment is difficult and expensive, complications are common, and the outcome is often uncertain. Alkaline and acidic substances with pronounced corrosive potential are abused, the most common of which are hydrochloric acid, sulfuric acid, concentrated acetic acid, sodium hydroxide, sodium hypochlorite, salts of heavy metals (mercury chloride), etc.[3,5].

In the examination, esophagogastroduodenoscopy (EGD) and the consequent classification of findings are considered the gold standard for diagnosis. Some authors prefer computed tomography and uphold the opinion that urgent CT can provide more reliable and objective data on the prognosis and predictions of the formation of strictures in the upper GI tract in comparison to EGD. In addition, they consider urgent EGD of the upper GI tract not necessary after intoxication with corrosive substances [6,7].

Therapeutic management unfortunately still depends on the individual approach and usually includes antacids, antibiotics, corticosteroids, mitomycin C, artificial nutrition and surgical stenting.

The aim of this study was, by presenting the results from the literature as well as our own experience, to make a retrospective analysis of the knowledge, problems, and opportunities to improve the examination and medical management of acute corrosive poisonings.

Epidemiology

Despite the numerous legal changes in the field of production, sale and distribution, poisonings with corrosive substances are a serious problem for the health system. The adopted changes in the legislation and the progress in the educational initiatives, including citizens' education, did not bring significant improvements in the frequency of corrosive poisonings and the subsequent complications they cause.

Our study has shown that women are more likely to abuse corrosive substances, patients are usually between 20 and 75 years old, the causes of poisoning in most patients are suicide attempts and the most used agent is hydrochloric acid (Table 1). Similar or identical results were obtained in studies conducted in Iran, Great Britain, Tunisia, China, Taiwan, and Bangladesh[8-11].

Table1. Patients' clinical features

	n	**(%)**
Total number of corrosive poisonings	640	(72.8)
Hospitalized patients	466	(5.1)
Exitus letalis	24	
Men	172	(36.9)
Women	294	(63.09)
Age	17-88	(51.43± 17.82)
- **15-19**	14	(3.0)
- **20-74**	424	(90.9)
- **>75**	28	(6)
Quantity of ingested corrosive substance (ml)	10-50	(16.8± 8.6)
0-5	160	
5-10	54	
10-20	152	
20-30	82	
> 30 ml	18	
Cause of the poisoning		
- **Suicide attempt**	434	(93.13)
- **Accident**	32	(6.8)

Type of corrosive agent		
- **HCl**	237	(50.85)
- **NaOH**	55	(11.8)
- **CH_3COOH**	44	(9.4)
- **Detergent**	24	(5.1)
- **$NaCLO_4$**	79	(16.95)
- **$Ca(OH)_2$**	7	(1.5)
- **Degreaser**	20	(4.2)
Degree of injury		
- **I**	42	(9.01)
- **IIA**	172	(36.9)
- **IIB**	137	(29.39)
- **III**	97	(20.81)
- **IV**	18	(3.86)
Late post-corrosive complications	69	(14.8)

The most common causes of death are perforation of the esophagus or stomach and subsequent onset of mediastinitis or peritonitis. Most of the patients died in the first 96 hours after hospitalization and only two of them died due to systemic complications (chronic renal failure and cardiac arrest) (Table 2).

Table 2. Positive correlation between poisonings with corrosive substances and percentage of late post-corrosive complications

Corrosive agent	Gastric stenoses	Esophageal stenoses	Gastric & esophageal stenoses	Exitus letalis	<96 post-ingestion	> 96 h post-ingestion
HCl	13	22	9	18	22	1
NaOH	2	14	4	5	/	
CH_3COOH	1	2	2	1	/	1
$NaCLO_4$	/	/	/	/	/	/
Detergent	/	/	/	/	/	/
$NaCLO_4$	/	/	/	/	/	/
Ca(OH)2	/	/	/	/	/	/
Degreaser	/	/	/	/	/	/

Material and methods

Our study was based on a review of our clinical material, as a retrospective cross-sectional study, and experience in the management of acute corrosive poisonings, a review of the articles included in the PubMed and Google Scholar databases, monographs, textbooks, as well as papers, and articles published in scientific journals. More recent data were taken into consideration and only papers and articles on acute corrosive poisonings in adults were reviewed.

Corrosive substances

Poisonings with corrosive substances can happen by oral ingestion, inhalation, or direct physical contact with the skin or eyes. Acute oral corrosive poisonings occur after ingestion of chemical substances. Many countries in the world are organizing educational programs for the population about the dangers of corrosive substances and are committed to improving packaging and protecting them from child abuse.

Acids such as hydrochloric, acetic, and sulfuric are the most abused acids in our environment (more than 50%). They are easily accessible and can be bought commercially as sanitary cleaners, food supplement, and canning material for fruit and vegetables. In addition to these substances, sodium hypochlorite ($NaCLO_4$) is also abused, and it is usually found in sanitary products combined with hydrochloric acid.

These corrosive substances also predominate in intoxicated patients from Taiwan and India, in contrast to the United Stated where poisonings with these corrosives were less than 5%. Sodium hydrochloride (bleach), oxalic acid (antioxidant), and hydrogen peroxide (cosmetic agent) were less commonly abused [14].

Less frequently seen intoxications can happen after a contact with corrosive alkalis, or bases such as sodium hydroxide (NaOH), potassium hydroxide (KOH), and ammonium hydroxide (NH4OH), used in households and industry. Their abuse is often seen in the United States and the European Union member states, and commercially they are found in granular and paste form. They have a high pH value, a concentration ranging from 4% to 54%, and have been found to be components in detergents, soaps, tablets for cleaning lavatories, or as drain cleaners. In recent years, poisonings due to ingestion of detergent capsules in different colors have been seen among children. They contain a concentrated detergent that can cause severe injuries to the upper GI tract [15,16].

Pathophysiology

The severity of the injury in the upper gastrointestinal tract depends on several factors, such as the type of corrosive agent ingested, the amount and concentration, the pH value, the duration of exposure and contact with the affected tissues, the act of swallowing, and the current state of the tissues[17]. Solutions with a pH lower than 2 or higher than 12 are highly corrosive and can cause life-threatening chemical burns. Most severe damages can be located in the esophageal and gastric areas, especially at their physiological narrowing. The path of the corrosive agent through the gastrointestinal tract leads to a severe damage to the mouth, throat, esophagus, stomach, and duodenum[16].

Upon contact of acids with tissue proteins, they are transformed into acid proteinates and hemoglobin is converted to hematin, with the result being so-called coagulation necrosis. When the tissue comes into contact with bases, the proteins from the tissues turn into proteinates and the fats turn into soaps; in both cases, the so-called penetrating or colliquative necrosis occurs[19]. The acute phase is characterized by the processes of inflammation and thrombosis. In the latent phase, granulation tissue is developed and intense collagen deposition begins after the third week post-intoxication. Finally, in the chronic scarring phase, at the end of the third week after ingestion, there is fibrosis and organization of the tissue, resulting in narrowing of the lumen of the esophagus or the stomach and the formation of stenosis and strictures. This process can last up to 3-6 months[20].

Corrosive injuries can be classified similar to the skin burns in three degrees. The first degree is characterized by superficial damage, edema, and erythema of the mucosa. The affected mucosa regenerates in a few days and usually heals without additional complications. In the second degree, the corrosive penetrates through the mucosa into the submucosa and the muscular layer of the hollow organ. After one to two weeks, deep ulcers form in the wall of the esophagus and stomach, granulation occurs, a fibroblastic reaction occurs, and collagen tissue is produced which contracts after several weeks or months. The third degree is characterized by perforation of the esophagus and stomach[21].

Clinical manifestations

Clinical signs and symptoms appear immediately after ingestion of the corrosive agent. The changes that occur are most objectively evaluated with the help of EGD.

Clinically, pain and burning in the mouth, throat, behind the sternum, and the upper abdomen are dominant. In addition, common symptoms also include laryngospasm, dysphonia/aphonia, dyspnea, hypersalivation, nausea, and vomiting, sometimes even with blood in the vomited contents. When swallowing, patients often experience aspiration of the corrosive substance to a greater or lesser amount, resulting in hoarseness, stridor, as well as a persistent and irritating cough. Aspiration of a large amount of the corrosive agent can cause acute tracheal necrosis which is one of the most common causes of death in the first few hours after ingestion[22,23]. Extensive injuries can cause the most severe acute complications, mediastinitis and peritonitis. The extensity of the upper gastrointestinal changes is considered a predictor of the outcome, although this still remains a scientific dilemma[24].

As a part of the early post-corrosive complications, subcutaneous emphysema may occur due to acute injury to the upper respiratory tract (Figure 1).

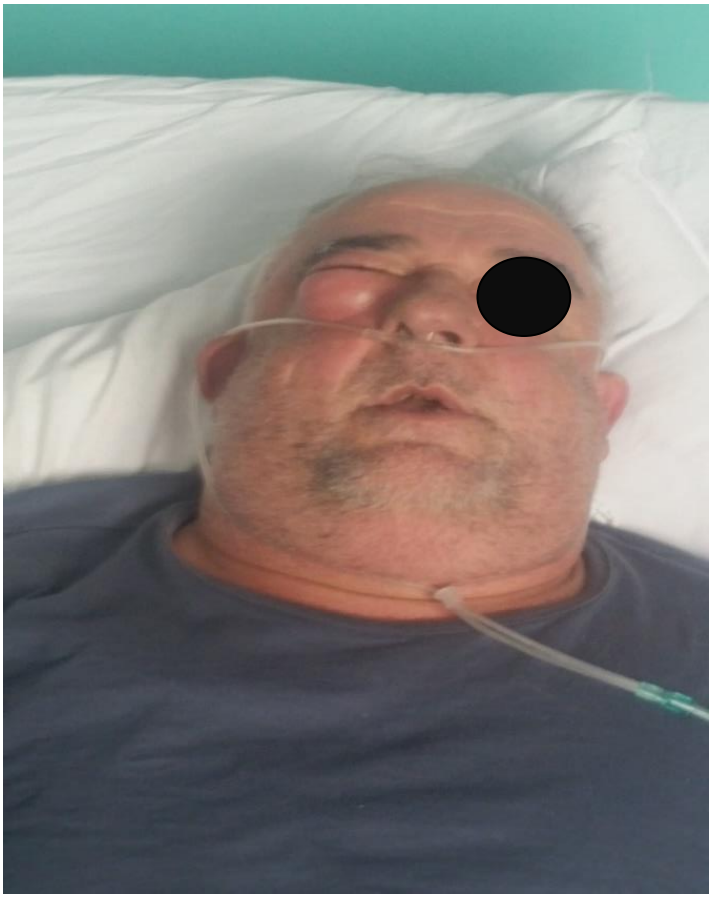

Fig. 1. Subcutaneous emphysema in a corrosive poisoning patient

Patients who survive the acute phase, in a large percentage ranging from 20% to 80%, and according to other authors from 70%-100%, may develop late post-corrosive complications. The most common of these are gastrointestinal reflux due to impaired tone of the lower esophageal sphincter, strictures or stenoses of the esophagus, stenosis of the antral or pyloric part of the stomach where patients often complain of rapid satiety and vomiting, nausea, heaviness, weight loss[25,26].

Post-corrosive injuries of the upper gastrointestinal tract can be immediately determined by an urgent upper endoscopy. Injuries are classified according to several classifications, the most commonly used being the Zargar and Kikendall classifications (Tables 3 and 4).

Table 3. Kikendall endoscopic classification

I	Mucous edema and erythema
II A	Hemorrhage, erosions, superficial ulcerations
II B	Circumferential lesions
III	Deep gray or brown-black ulcers
IV	Perforation

Table 4. Zargar endoscopic classification

0	Normal mucosa
I	Mucous edema and erythema
II A	Hemorrhage, erosions, superficial ulcerations
II B	Circumferential lesions, ulcers, hemorrhage
III A	Deep gray or brown black ulcers
III B	Extensive necrosis

*Kikendall JW. Caustic ingestion injuries. *Gastroenterol Clin North Am* 1991; 20(4): 847-857. PMID: 1787017.
*Zargar SA, Kuchhar R, Mehta S, *et al*. The role of fibroptic endoscopy in the management of corrosive ingestion and modified endoscopic classification of burns. Gastrointest Endosc. 1991; 37:165-169.

The predictability of the outcome, the need for hospitalization in the intensive care unit, and the need for surgery, or fatal outcome will largely depend on the concentration of the corrosive agent, the motive for abuse - accident or suicide, and the degree of post-corrosive damage[27, 28].

Clinical examinations and prognosis

All patients with a history of corrosive substance contact should be medically monitored and hospitalized in units for intensive care. Efforts are made to obtain information on the quantity and chemical composition of the ingested chemical, the motive for which it was abused, the time of ingestion, the concentration, and where it was obtained.

Clinical symptoms such as pain and burning behind the sternum and in the abdomen, nausea, vomiting, cough, and shortness of breath are noted. It is mandatory to request information on whether any manipulation has been performed before and during transport, such as induced vomiting, giving fluids or medications, or whether the original package of the misused product is provided. Local clinical examinations of the face, oral mucosa, and throat follow. The absence of local oropharyngeal injuries does not rule out the possibility of severe esophageal injury (Figure 2).

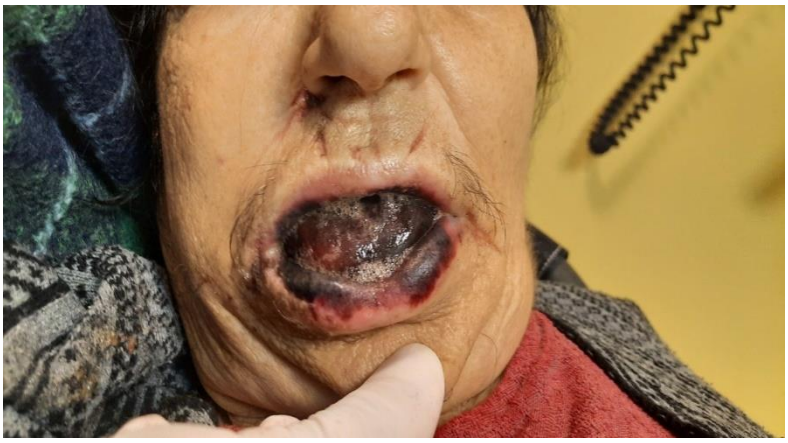

Fig. 2. Patient with severe local post-corrosive changes

In 10-30% of patients who have severe esophageal injuries, there is absence of local changes in the mouth and pharynx. Even in 70% of patients who have had severe local oropharyngeal injuries, no esophageal injuries have been detected.

The presence of hoarseness indicates a laryngeal, epiglottic, or hypopharyngeal complication. The onset of fever indicates perforation and requires consultation with an abdominal and thoracic surgeon. Substance aspiration can cause endotracheal or bronchial necrosis, with mediastinitis being one of the most severe and often fatal complications[29,30]. Extensive changes in the laboratory status can be noted in patients with severe gastrointestinal bleeding, renal and hepatic failure. In the acute phase, X-ray of the chest and abdomen may show the presence of air in the mediastinum or under the diaphragm suggesting esophageal or gastric perforation. Radiological examination with gastrografin 25-30 days after ingestion may provide useful data on changes in the size of the lumen of the esophagus or stomach. Some practitioners prefer barium sulfate to gastrografin due to its less irritating nature in the event of contrast aspiration[31].

Upper endoscopy remains the gold standard for diagnosis and assessment of acute corrosive poisoning and is performed in the first 24 hours, although there are suggestions that it may be performed within the first 6 or up to 96 hours after ingestion. After 4 days, endoscopic examination is not recommended because in the period from 4 to 12 days after ingestion the healing of the injuries is most intense and there is a danger of iatrogenic injuries with unpredictable consequences, mainly bleeding from the upper part of the gastrointestinal tract (GI). After endoscopic examination, it is useful to classify the injuries according to Zargar or Kikendall, to continue with the examinations and to make a treatment plan[32,33].

Some authors believe that CT of the esophagus and stomach can eliminate or alleviate the negative sides of esophagogastroduodenoscopies such as invasiveness and possible contraindications for performance in some patients. Clinical studies have provided encouraging information that CT has yielded more reliable findings on whether the appropriate patient should undergo emergency surgery and thus significantly improved the predictability and stratification of patients with acute corrosive poisonings. The recommendations of some authors that MR imaging can provide useful information about injuries to the upper part of the GI tract have not been widely used[34].

Treatment

In acute corrosive poisoning, a common cause of death is acute post-corrosive injury or complications of the upper respiratory tract. It usually occurs due to aspiration of the corrosive or due to extensive post-corrosive changes in the upper part of the GI tract and it is complicated by indirect injuries to the respiratory tract. Therefore, when admitting a patient who has ingested a corrosive substance, the priority should be to provide a passable airway without signs of spasm or perforation, and if such changes or shortness of breath are found, to immediately provide a free airway with therapy or endotracheal intubation[35-37].

Medical charcoal has no significance in this poisoning because it does not absorb the corrosive agent and may also prevent adequate upper endoscopy. Gastric lavage is mandatory contraindicated.

Due to frequent vomiting and sometimes diarrhea, strict monitoring of the hemodynamic status of these patients is recommended, as they can lose a large amount of fluid very quickly, which will further aggravate the already difficult condition. It is therefore recommended to give a large amount of fluid (3000-4000 ml) parenterally, including electrolyte substitution. Some studies also recommend the installation of a nasogastric tube blind, which is a rather risky and still controversial procedure due to the possibility of iatrogenic injuries[38,39].

Corticosteroids have long been used in the treatment of acute corrosive poisonings, especially in children, as they have been shown to help prevent late post-corrosive complications such as stenosis and stricture. This has been supported by numerous studies, although opinions have been contradictory.

However, recent controlled clinical trials have shown that corticosteroids do not have a particularly beneficial effect on the formation of stenoses, and there is a general belief that corticosteroids in the treatment of acute corrosive poisoning should be omitted until their beneficial effects are proven by new, more comprehensive studies including a larger number of patients[40,41]. Other pharmacotherapy includes antacids, sucralfate, antibiotics, and mitomycin.

In the acute phase after ingestion, in regular therapy H_2 blockers or proton pump inhibitors are given in high doses, although the justification for their application has not been proven in a large number of controlled clinical trials. They are given because of their suppressive effect on the secretion of gastric acids and the possible inhibition of additional injuries. Several clinical studies have shown that the administration of sucralfate in acute corrosive poisoning may reduce the risk of post-corrosive inflammation of the upper gastrointestinal tract.

Sucralfate is thought to improve the blood supply and resistance of the mucosa in the upper part of the GI tract and provide physical protection from the adverse effects of the corrosive substance. However, for its beneficial effect, additional research should be done. In recent years, the administration of mitomycin C, which is thought to inhibit fibroblast activity and thus slow the development of late post corrosive complications, has been recommended. It is especially recommended when performing active methods of dilatation of already formed stenosis[42-47].

After 15 days of ingestion, some authors recommend active treatment methods that are used to prevent the formation of stenoses and allow patients to be physiologically feed. These active methods are the so-called retrograde intraluminal esophageal dilatation or implant of an esophageal intraluminal stent. These two methods dilate the already existing stenoses or prevent the possibility of stenosis formation. Some authors perform these methods 15 days after ingestion, but the prevailing view is that dilation and stenting are best performed 6 weeks after ingestion due to the high risk of iatrogenic injury or perforation[48,49].

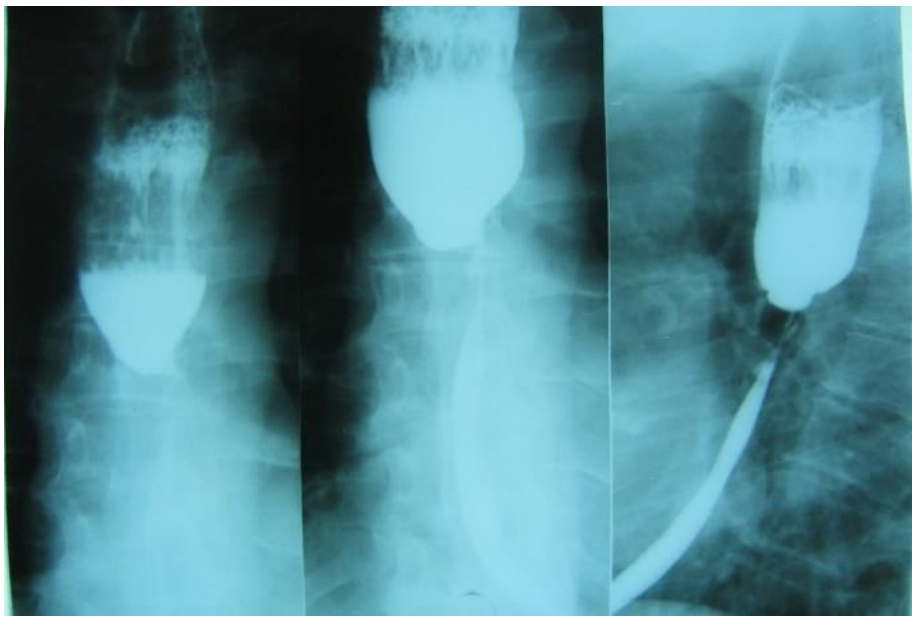

Fig. 3. X-ray finding of middle and distal esophageal stenosis

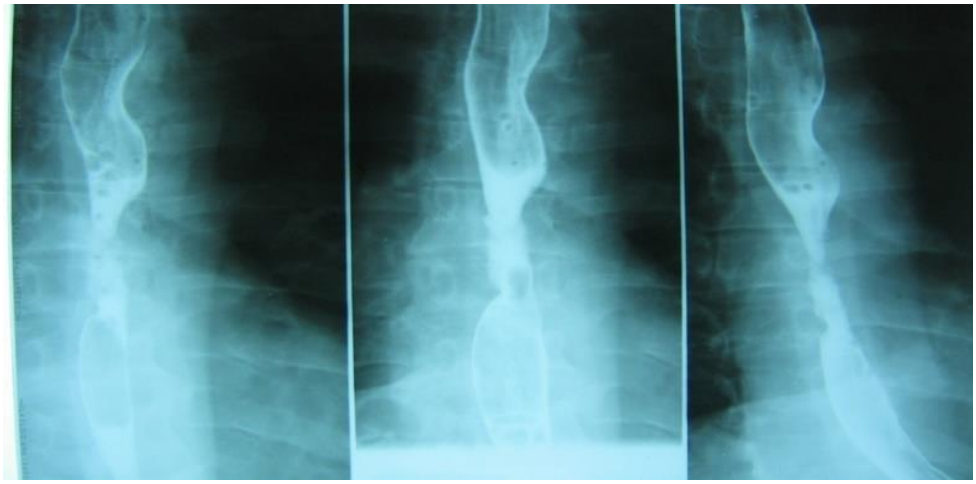

Fig. 4. X-ray finding after retrograde intraluminal dilation

Artificial nutrition (clinical nutrition)

The artificial diet has special importance in the treatment of corrosive poisonings. Severe damage to the upper GI tract prevents normal nutrition in these patients. They are in a severe condition due to the nutritional status accompanied by a hypercatabolic state and negative nitrogen balance; therefore, early nutritional support is of great importance in the treatment. Artificial nutrition is a life support therapy for patients who are unable to take food by mouth and who are at constant risk of malnutrition. The effects of artificial nutrition in patients with life-threatening diseases are multiple, such as a reduction of the possibility of infections and bacterial translocation, and a reduction of the predisposition to aspiration pneumonia and pulmonary embolism. Therefore, early nutritional support is of great importance in the outcome of the poisoning and treatment of these patients[50,51].

The type of artificial support will depend on the endoscopically determined degree of damage of the esophagus or stomach. In patients with IA and IIA degree of damage, after 24-48 hours of total parenteral nutrition, feeding is continued with a liquid diet for up to 10 days. After that, food intake can be liberalized. In patients with IIB and III degrees of post-corrosive damages, the so called “esophageal rest” or NPO (nil per os) regimen is applied. During rest, the patient is fed parenterally via peripheral or central vein and enterally via nasogastric or nasoenteral tube, gastrostomy, or jejunostomy. Esophageal rest can be maintained up to the tenth day after ingestion or, according to some authors, up to 15 days or until the first control endoscopic examination[52]. Parenteral peripheral vein nutrition is performed for a limited period of time, which should not exceed 10 days. If there is a need to continue the nutritional support, it is continued through the central vein. Parenteral nutrition is of great importance in the nutrition of corrosive poisonings at the beginning of hospitalization, but long-term use carries certain risks and the possibility of complications such as thrombophlebitis of peripheral veins as well as a pathway for infections through the central veins.

Enteric nutrition is a way of feeding when food enters directly into the GI tract through specially designed tubes called enterostomas. The nasojejunal tubes are used for a diet that is not expected to last longer than 30 days, while if there is an indication for a diet that lasts longer than 30 days, then an enterostomy is installed (Figure 5).

The greatest progress in nutritional support has been made in the last ten years when certain modern nutritional products have been created in which the complications in the implementation of the nutritional support have been minimized[53].

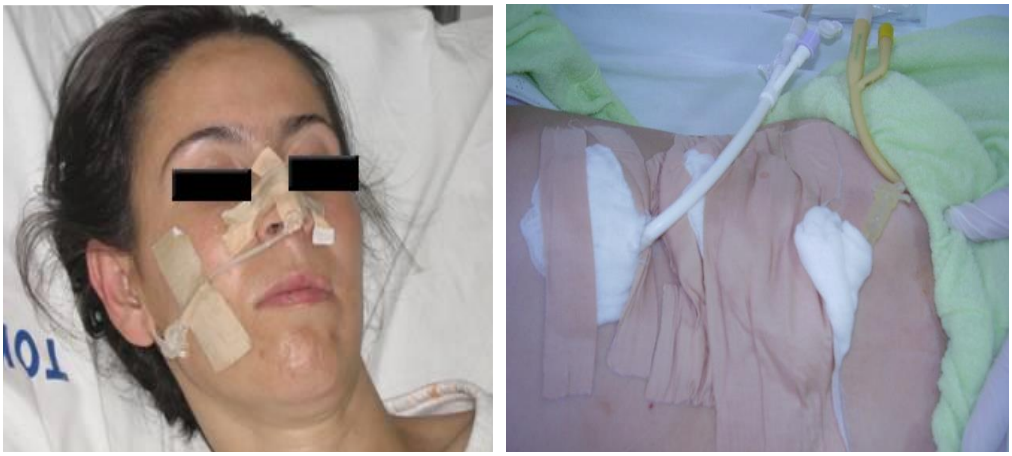

Fig. 5. Patient with nasojejunal probe and patient with gastrojejunostomy

Surgical treatment

Surgery is indicated when:

- There is complete stenosis that cannot be resolved with the usual conservative methods
- There is a defect of the esophagus or stomach detected by a radiological examination
- Development of a severe paraesophageal reaction with mediastinitis or peritonitis
- Fistula formation

In the surgical approach to complications caused by ingestion of corrosive chemicals, the most commonly used methods are colon interposition, resection of the esophagus or stomach, and gastrectomy.

Recommendations

Despite the good results of screening and modern treatment of patients with acute corrosive pointing, the American Gastrointestinal Surgery Association (ASGE) gives several recommendations for monitoring patients with caustic upper gastrointestinal injuries:

- Supervision of patients 15-20 years after ingestion
- Endoscopic examinations every three years.

Prognosis

Prognosis in acute corrosive poisonings is variable and depends on the degree of esophageal or gastric damage as well as patients' previous general health. The highest mortality rate is due to the consequences of perforation and mediastinitis.

Highlights

Acute corrosive poisonings remain an important issue in the modern clinical toxicology. They still present with high mortality rates and serious, long-term complications. Scientific efforts should be made in order to conduct more extensive investigations and implement modern treatment protocols, based on a large body of evidence.

Conflict of interest statement. None declared.

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