*Int. J. Electrochem. Sci.*, 7 **(2012)** 1734 - 1748

International Journal of
ELECTROCHEMICAL
SCIENCE
www.electrochemsci.org

# Consequences of Ingestions of Potentially Corrosive Cleaning Products, One-Year Follow-Up

*Karolina Mrazová* [1], *Tomáš Navrátil* [2,*], *Daniela Pelclová* [1]

[1] Toxicological Information Centre, Department of Occupational Medicine of the First Faculty of Medicine, Charles University in Prague and General University Hospital, Na Bojišti 1, 120 00 Prague, Czech Republic;
[2] J. Heyrovský Institute of Physical Chemistry of ASCR, v.v.i., Dolejškova 3, 182 23 Prague 8, Czech Republic
[*] E-mail: navratil@jh-inst.cas.cz

*Received:* 17 July 2011 / *Accepted:* 23 November 2011 / *Published:* 1 March 2012

---

Cleaning products are responsible for many accidental exposures among children and adults and depending on the composition, they may cause a corrosive damage. In this study we focused on the counts, consequences of exposures to the products, symptoms, first aid and treatment provided with special attention to the products the label of which did not correspond to the detailed composition of the product in the Material Safety Data Sheets. The outcomes of exposures of cleaning household products have been collected in a prospective study during one year based on the calls to the Czech Toxicological Information Centre between January 1, 2009 and December 31, 2009. Cleaning products were divided into five categories according to their use and chemical characteristics. Altogether 40 subjects were admitted to the hospital. Total 31 endoscopy (ES) were performed. ES findings brought normal finding in 12 cases, 1st grade in 17. In only two patients 2nd - 3rd grade injuries of the gastrointestinal tract (GIT) were found. The label of all cleaning products should show the contents and percentage of all hazardous substances. The dose is frequently uncertain and the broad corrosives composition range and unreliable labeling may contribute to futile hospitalizations and ES in both children and adults. For characterization of potential consequences which could be caused by ingestion of these cleaning products or skin contaminations by them, the electrochemical pH determination and determination of titrable solution reserve were suggested.

---

**Keywords:** Czech Toxicological Information Centre (Czech TIC), Cleaning products, consequences, pH determination, Titrable acid/alkaline reserve

## 1. INTRODUCTION

Cleaning products stored in the homes are responsible for many accidental exposures among children and adults and represent a problem of a huge magnitude, as they are a persistent cause of admissions to Emergency Departments of the hospitals. In addition, endoscopy (ES) of the oesophagus, stomach and duodenum is frequently needed to evaluate the severity of corrosive damage and to decide about further treatment. Exposures, which mostly take place in the home, may be related to many easily available cleaning products, containing harmless anionic and non-ionic detergents on one side, bleaches with irritating properties, and potentially corrosive chemicals on the other side [1]. Understandably, the damage is usually extensive in case of intentional ingestions, when a large amount of a caustic product is swallowed. Unfortunately, there is still some controversy concerning first aid [2, 3] and treatment of caustic ingestions [2, 4, 5].

According to the national legislation, if the cleaning product contains hazardous components, the producers are obliged to specify these ingredients and their percentage in the Material Safety Data Sheet (MSDS). This written document provides vital information concerning safe use, handling, and storage. However, the above mentioned ingredients and their percentage do not always appear on the label accurately and consistently. There is sometimes a discrepancy between the compositions of the product described by MSDS and between the labels of the cleaner. For instance, the corrosive ingredients, such as sodium hydroxide (if less than 1-5 per cent), are missing on the label as if their damaging role would be negligible. Unfortunately, even Czech legislation leaves some gaps for such behavior of the chemical companies and it lacks sufficient activity of supervisory authorities.

Therefore, in this study, we also focused on the counts, consequences of exposures to the products, symptoms, first aid, and treatment provided with a special attention to the products the label of which did not correspond to the detailed composition of the product in the MSDS. Determination of the pH and titratable reserve we evaluated in groups of descalers. However, as it was found in the group of descalers [25], the determined pH value must be combined with other physical-chemical parameters, e.g., viscosity, concentration of consequential ingredients, amount ingested, contact time, and premorbid state of the esophagus, which may contribute to the outcome of injury, no marker exists to accurately predict a product's potential for injury [3, 26, 27]. From the toxicological point of view, pH often fails to predict the extent of injury after exposure [25] and in correspondence with our results, reliance on pH alone might result in clinical errors in patient management [3]. Therefore, parameter denoted as titratable acid reserve (TAR) (or water acidity) was suggested as more appropriate estimate of the corrosive potential [3, 27, 28]. Similarly, titrable alkaline reserve can be used for characterization of the alkaline solutions [3]. TAR is defined as the ability of sample to neutralize alkaline reacting compounds, e.g., NaOH. “Total TAR” corresponds to the sum of carbon dioxide and all present acids (humin acids, limescale removers, etc.) [29].

The analytical and physical-chemical methods, based on electrochemical principles, proved to be very suitable for characterization and determination of composition of environmentally important compounds, e.g., [6-18]. Of course, for determination and analysis of toxic compound the special sophisticated devices have been developed for many decades, e.g., [6, 19, 20]. On the other hand, in many cases, the relatively simple electrochemical, we can call them traditional, method and devices can be successfully utilizes. As it is known, determination of pH belongs to one of the oldest and the most reliable electrochemical methods, which has been improved and developed up to these days (e.g., [21-24]).

Our aim was to ascertain, whether there is some risk of corrosive damage of the gastrointestinal tract (GIT), as incomplete information might lead to the underestimation of the exposure and delayed treatment. In addition, the recommendation for hospitalization and endoscopy (ES) of the GIT was compared with the suggestions done by the TIC.

## 2. METHODS

Data concerning exposures of cleaning household products, recorded into the database (programmed in MS Access 2003) of the calls to the Czech Toxicological Information Centre (TIC), were collected in a prospective study during one year (January 1, 2009 till December 31, 2009). TIC is the only center in the country and covers the population of about 10 million inhabitants. Cleaning products with irritating or potentially corrosive effects were divided into five categories according to their use and chemical characteristics.

In every inquiry, following data concerning the exposure was recorded according to the standard protocol, i.e.: age and sex of the patient, time of the exposure, estimated dose, symptoms [30], and the information whether first aid and any treatment had already been administered. Besides that, the prognosis of the patient at the time of the call was evaluated and, further management and therapy recommended, if needed. In all cleaning products, the composition declared on the label was compared with the composition in the MSDS.

In addition, a follow-up call within no longer than 2 weeks has been performed and the clinical course was evaluated. If the patient was hospitalized, the discharge report from the hospital was asked for the evaluation of the outcome.

Statistical methods: Basic one-dimensional statistical tests (arithmetic mean, standard deviation, confidence interval, etc.) and chi-square test (calculated using MS Excel (Microsoft Inc., USA) and QC expert (Trilobyte s.r.o., Czech Republic).

pH were determined with a digital pH-meter "WTW inoLab-Level 2" (inoLab, CR) applying a combined glass/calomel reference electrode (Schott - BlueLine). All measurements were performed at room temperature.

The severity in terms of reaction of four of the commercial descalers (denoted A to D) were characterized by comparison of time and temperature changes of pH and their TAR. All solutions were prepared according to the instructions as recommended by the manufacturer.

## 3. RESULTS

In the year 2009, Czech TIC answered total 9411 calls, among them 686 inquiries due to cleaning products, including 258 calls concerning cleaning products with irritating and potentially corrosive properties. There were 118 exposed males and 140 females, females being slightly prevalent both among children (51.8%) and adults (57.1%). Among children, the most endangered age group was the youngest group of 0-3 years, as can be seen in Fig. 1.

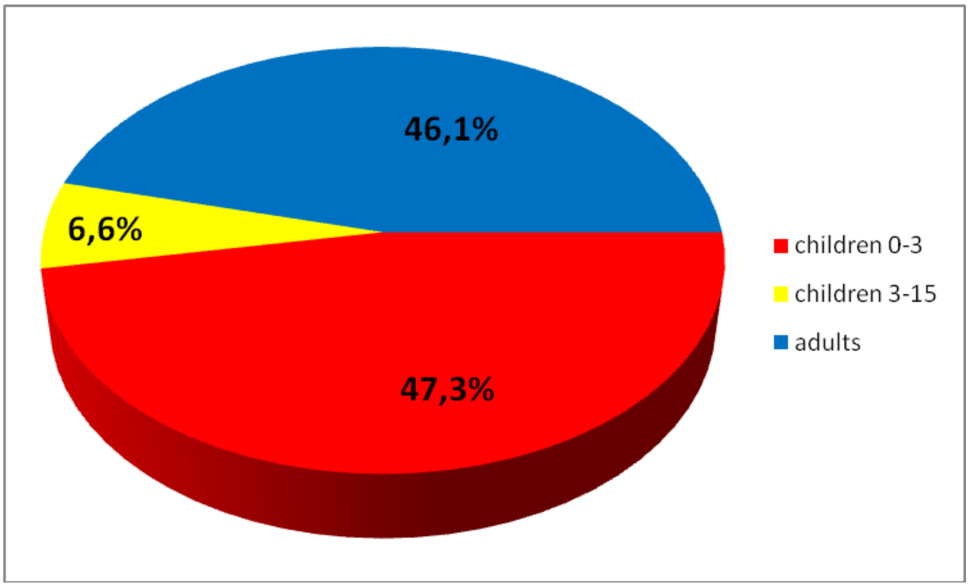


**Figure 1.** Age groups of the subjects exposed to cleaning household products.

Overview of the main components of cleaning products (except for group of Descalers), to which the subjects were exposed, is shown in Tab. 1.

Four different Descalers were analyzed. Their compositions are as follows: Descaler A (0.1 L diluted by 0.3 L of water): citric acid (CA) 30 %, tensides 2%; Descaler B: amidosulphonic acid (ASA) 5-15 %; Descaler C: phosphoric acid (2%), ethoxylated alcohols (3.5%), Descaler D: ASA 5-15 %, ortophosphoric acid (OPA) 5 %, tensides 2 % (0.2 L diluted by 0.8 L of water).

**Table 1.** Overview of the cleaning products followed in our study.

| **Drain cleaners** | **Product A (83%)** | **98.5% sodium hydroxide** |
|---|---|---|
| | Product B (11%) | < 10% sodium hypochlorite, < 3.5% sodium hydroxide |
| | Product C (6%) | < 10% sodium hypochlorite, < 5% potassium hydroxide, < 20% potassium silicate |
| Oven and grill cleaners | All products | 5-10% sodium hydroxide, 15% surfactants |
| Dishwasher powder and tablets | Product A (58%) | 11.9% sodium carbonate, 11.0% sodium perborate, 5.1% aliphatic alcohol, < 0.2% perfume, < 0.1% diastase |
| | Product B (42%) | < 25% sodium carbonate, < 20% sodium perborate, < 5% disodium silicate, < 5% zinc acetate |
| Sodium hypochlorite products | All products | < 5% sodium hypochlorite, <1% sodium hydroxide |

The groups of Drain cleaners, Dishwasher group, and the group of Descalers contained several products, the composition of which slightly differed.

Most of the inquiries (69%) concerning exposures to cleaning products have been asked within one hour after exposure. The calls came more frequently from the medical professionals (70.5%) than from the general public (29.5%).

The exposure was accidental in all children (100%) and majority of the adults (86.4%). In adults, 10.1% of exposures related to inhalation at housework in confined spaces (cleaning bathrooms and toilets). About 2% (5 adults) inquiries involved suicide attempts among them, 3 chose ingestion of sodium hypochlorite products with less than 1% sodium hydroxide and two ingested drain cleaners.

First aid after exposure had been provided already before the call to TIC in 36.4% of cases. After ingestion it included: washing of the mouth (50 cases, i.e. in 24.4 % of all ingestions) and/or drinking water (34 cases, i.e. in 16.6 % of all ingestions). Neutralization has not been performed in any case. First aid after inhalational exposure included rescuing the person to the fresh air or opening the windows (10 cases, i.e. 38.5 % of all inhalational exposure).

Approximately 57% of exposures to cleaning products were symptomless; symptomatic subjects after ingestion complained of throat ache, sore throat, nausea, and vomiting, the main symptoms after inhalation were cough, dyspnea. Symptoms severity grade was evaluated as minor in 39.5% and moderate merely in 3% of the calls [31]. Only one subject (Patient 1) developed severe symptoms, as can be seen in Tab. 2.

Eventually, 40 subjects (15.5%) were admitted to the hospital (27 children, i.e.19.5% of all children, 13 adults, i.e. 10.9% of all adults). On average, patients were hospitalized for 1 week (2–14 days). The longest hospitalizations occurred in drain cleaners and sodium hypochlorite products. The proportion of hospitalization for exposure to different product categories is shown in Fig. 2.

**Table 2.** The outcome of exposures to cleaning household products categories in children and adults *(Inhalation at housework is included in the parenthesis)*

| Category of products/Symptoms | Serious | Moderate | Minor | No symptoms | Total |
|---|---|---|---|---|---|
| Children | | | | | |
| Drain cleaners | 1 | 4 | 8 | 0 | 13 |
| Oven and grill cleaners | | | 1 | 2 | 3 |
| Dishwasher powder and tablets | | | 14 | 50 | 64 |
| Sodium hypochlorite products | | | 9 | 34 | 43 |
| Descalers | | | 2 | 14 | 16 |
| Adults | | | | | |
| Drain cleaners | | 1 | 4 | | 5 |
| Oven and grill cleaners | | | 4 | | 4 |
| Sodium hypochlorite products | | 2 | 38 (26) | 12 | 52 |
| Descalers | | | 22 | 36 | 58 |
| Total | 1 | 7 | 102 | 148 | 258 |

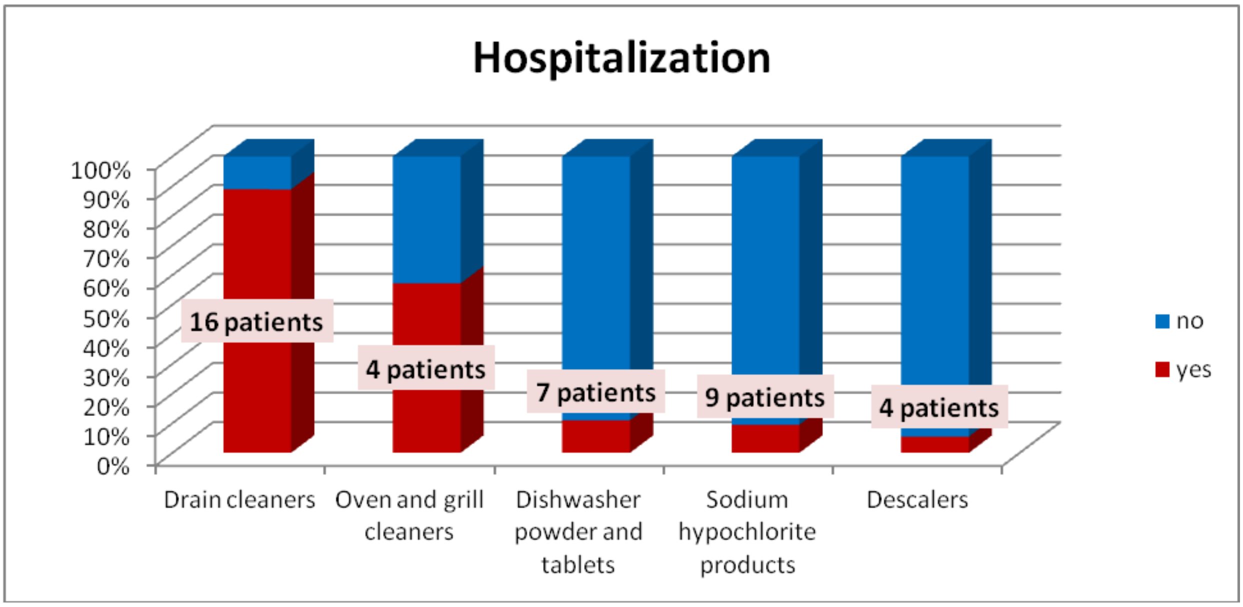


**Figure 2**. The proportion of hospitalization for different product categories and the numbers of patients involved.

Total 31 ES (12% of all cases) were performed, 16 in children 0-3 years, 4 in children 4-15 years and 11 in adults. The management involved observation of the patient in the department and a soft food diet. The percentages of ES according to the group of cleaning products are shown in Fig. 3.

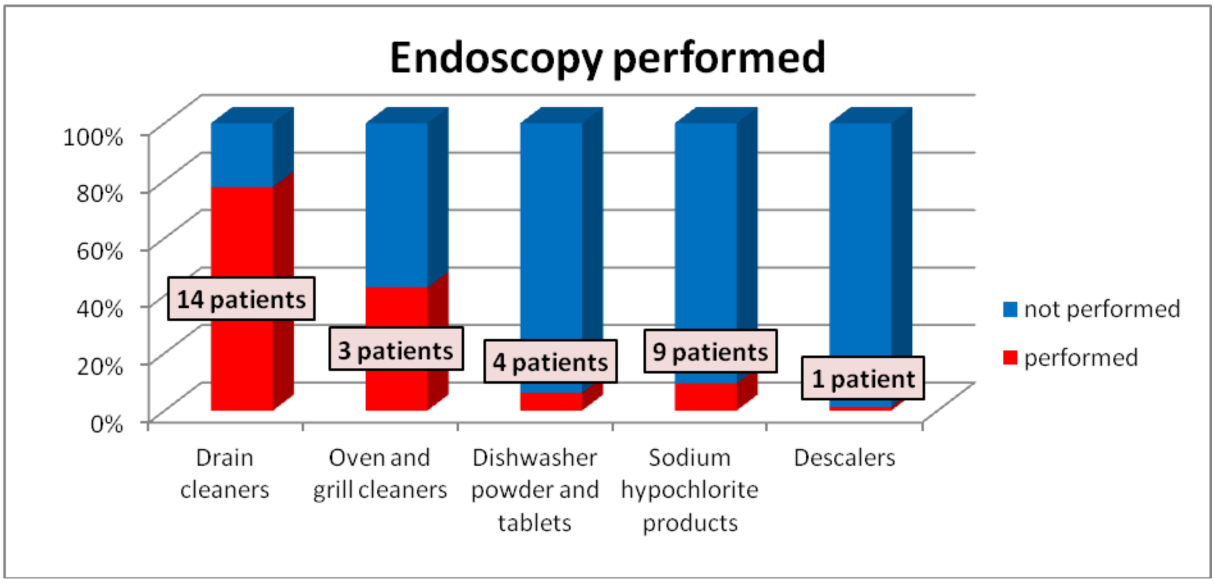


**Figure 3.** Endoscopies, performed after exposures to the categories of cleaning products and the numbers of patients involved.

ES findings after both non-intentional and intentional exposures to individual groups of cleaning products in children and adults brought normal finding in 12 cases, 1 st grade in 17. In only two patients 2nd-3rd grade injuries of the GIT were found. These male subjects ingested liquid drain cleaners; both drank water for first aid later on, however both had to repeatedly undergo ES (Tab. 3).

Patient 1 was a 5year-old boy who ingested several sips of industrial liquid drain cleaner, which his mother had been using (< 5% potassium hydroxide, < 20% potassium silicate, and < 10% sodium hypochlorite). His mother brought this cleaner from the farm, where it was used for cleaning and disinfection of milk tanks and piping systems. It was poured from the original container into a soft drink bottle. During the admission to the emergency department the boy had a throat ache, swelling of the throat and face, drooling, followed by vomiting a bloody gastric content. His chest radiograph was normal. His ES showed corrosive damage of the oral cavity, extensive damage of both the esophagus and the stomach, grade 3.

Immediately, he received corticosteroids (dose 20 mg daily, the therapy was gradually terminated in the late 4 weeks), hemostyptics, antibiotics, and he was intubated for 4 days. Five weeks later, an eosophagus stricture developed and repeated balloon dilatations had to be performed.

Patient 2 was a 38year-old man, who ingested the liquid drain cleaner (< 3.5% sodium hydroxide, <10% sodium hypochlorite) for a suicide attempt, and had a throat ache at the time of the call. ES showed corrosive eosophagitis, gastritis, and duodenitis with white eschars, grade 2.

This patient stayed at hospital for 8 days and recovered without sequels. He was treated with omeprazol, antibiotics and anxiolytics.

In the comparison of the label and MSDS composition data, our study, only the group of sodium hypochlorite products differed on the label and MSDS. In these products, sodium hydroxide up to 1 % was missing on the label.

**Table 3.** Endoscopy (ES) findings after ingestion of different categories of cleaning products in all children and adults *(Suicidal attempts are included in the parenthesis)*.

| ES Findings | Drain cleaners | Oven and grill cleaners | Dishwasher powder and tablets | Sodium hypochlorite products | Descalers | Total ES |
|---|---|---|---|---|---|---|
| Total children 0-3 | 8 | 3 | 61 | 36 | 14 | |
| ES Normal finding | 3 | | 4 | 2 | | 9 |
| ES 1st grade damage | 4 | 1 | | 2 | | 7 |
| Total children 3-15 | 5 | | 3 | 7 | 2 | |
| ES Normal finding | 2 | | | | | 2 |
| ES 1st grade damage | 1 | | | | | 1 |
| ES 2nd -3rd grade damage | 1* | | | | | 1 |
| Total Adults | 5 | 4 | | 52 | 58 | |
| ES Normal finding | | | | | 1 | 1 |
| ES 1st grade damage | 2 (1) | 2 | | 5 (3) | | 9 |
| ES 2nd -3rd grade damage | 1 (1) + | | | | | 1 |
| Summary | 18 | 7 | 64 | 95 | 74 | |

* *Patient 1 + Patient 2*

Water used to prepare tested descalers, amounted to pH 6.5 before boiling, and 7.0 after boiling. The pH-values of hot drinks prepared from descalers are summarized in Tab. 4.

**Table 4.** pH values of hot drinks (green tea, black tea and coffee), prepared from descalers.

| Remover | pH of green tea | pH of black tea | pH of coffee |
|---|---|---|---|
| Water, pH 6.5 | 6.2 | 6.0 | 6.4 |
| Remover C | 3.0 | 3.1 | 3.5 |
| Remover B | 2.8 | 2.9 | 3.0 |

TAR of descalers was examined in the following experiments. The amounts of NaOH necessary for achievements of chosen pH values in 100 mL of these products are depicted in Fig. 4.

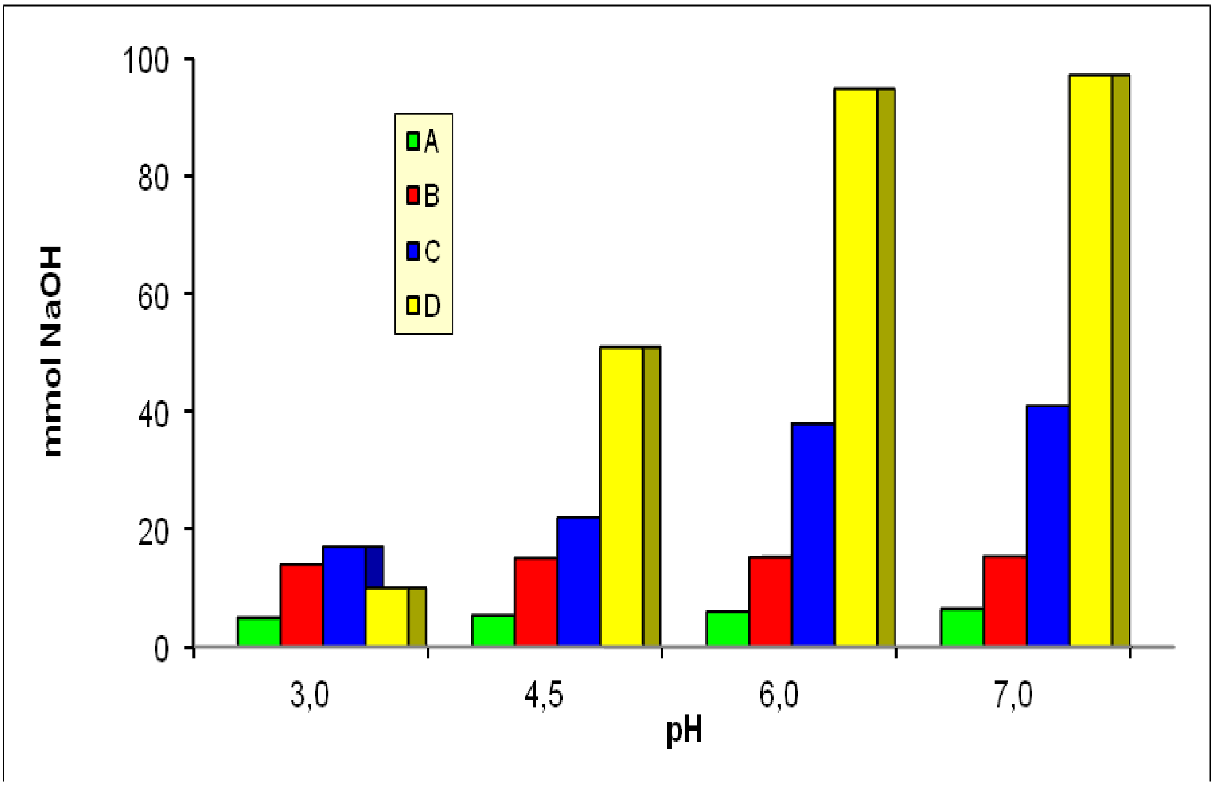


**Figure 4.** The amounts of NaOH, which it is necessary to add to 100 mL of tested descalers (A-D), composition in "Reagents and Materials") for achievement of chosen pH values.

The descaler solutions (prepared as recommended by the manufacturer) were placed into the kettle and its pH was recorded at the temperature 20 oC. The values were in the range of 1.4 to 2.9. To investigate the time influence, the remover solution were boiled, solutions were cooled down up to 20 oC and their pH values were registered for in following 24 hours (Tab. 5).

**Table 5.** The TAR for achievement of pH 6.50 of four studied group of descalers with a time interval of up to 24 hours.

| | Initial pH | TAR [mmol NaOH/100mL of solution] | | | | Percentage change of TAR [%] | | | |
|---|---|---|---|---|---|---|---|---|---|
| Remover | Time [hours] | 0 | 2 | 4 | 24 | 0 | 2 | 4 | 24 |
| Remover A | 2.7 | 11.7 | 11.9 | 11.8 | 11.6 | 0.0 % | 1.8 % | 0.9 % | -0.9 % |
| Remover B | 2.4 | 92.4 | 96.7 | 87.8 | 84.3 | 0.0 % | 4.7 % | -5.0 % | -8.8 % |
| Remover C | 2.0 | 38.0 | 38.5 | 38.1 | 38.0 | 0.0 % | 1.3 % | 0.3 % | 0.0 % |
| Remover D | 2.3 | 12.6 | 11.6 | 11.4 | 11.2 | 0.0 % | -8.3 % | -9.2 % | -10.8 % |

## 4. DISCUSSION

Exposures to irritating or corrosive agents are unfortunately very common in children in the age group between 0-3 years. Unintentional chemical injury is the leading cause of a long-term disability in pre-school children in Europe and the United States [32-34].

The producers fortunately react to the situation and try to replace the corrosive components with less dangerous ones, such as organic acids in descalers, and disilicates in dishwasher products. However, highly concentrated NaOH in the group of drain cleaners is still used and even the safety closures are not able to fully eliminate the problem, as can be seen from this study.

Obviously, 1% NaOH, as part products for disinfecting bathrooms and kitchens may cause corrosive damage when several sips are ingested. However, this study showed that the findings in accidental ingestions were minor or rather absent.

Low number of symptomatic subjects and patients with abnormal ES finding in this study might look positive on one side. However a large proportion of subjects had to be admitted to the hospital and had to undergo ES. The uncertainty of dose in many patients, especially children and the uncertainty of the real exact composition of the potentially corrosive products make the situation very difficult. Broad range of corrosive component as fulfilled in the MSDS and the non-reliability on the content written on the label, leads to unnecessary hospitalizations and ES, most commonly in children aged up to 3 years.

In this study the injury occurred most frequently in children between the ages of 1 to 3 years, and the exact ingested amount was frequently unknown, often probably very low, just lick. This is the reason for no or minor symptoms in most of the subjects.

Similarly in the accidental ingestion group of the adults, the amount of the ingested agent was fortunately low and no complications developed.

A high number of suspected injuries occurred due to a large spectrum of commercially used cleaners. The majority of them were packed in brightly colored and thus enticing bottles or boxes.

Historically, the rate and severity of caustic ingestion injury increased markedly with the introduction of liquid drain cleaners, because liquid alkalis can be swallowed in a significant quantity before the subject recognizes the mistake and experiences the symptoms [35]. Prior to this time, the ingestion of a solid crystalline or powder forms of these products tended to occur in smaller amounts because it was difficult to ingest much before severe pain ensued. The liquid forms also tend to cause more extensive circumferential burns of the oesophagus [36].

ES is considered a gold standard to diagnose corrosive burns in the GIT; and it should be performed until 24 hours after ingestion before the GIT wall becomes more fragile [36]. Most authors think that early ES is necessary to achieve the definite diagnosis and severity of an esophageal burn. They also mean that the prediction of the status of esophagus is not possible without an early ES [37, 38].

Only few authors, i.e. Bicakci et al. [39], suggest that ES should be reserved only for patients with feeding problems after caustic ingestion. He argues that in practice, the findings at ES rarely bring useful data to change the treatment strategy of the patient. An unnecessary general anesthesia and possible complications of the ES at the most fragile period of esophagus may be avoided.

Also according to Janousek et al. [40], the oesophageal injury may have a devastating influence on the individual with later implications on health**.** The endoscopic findings were positive in 44 % of their children with suspected corrosive injury. For this reason, they recommend an early ES in all children suspected of ingesting corrosive chemicals.

According to Toxbase [41] the fibreoptic ES by an experienced endoscopist is indicated to grade the severity of the injury in a patient with any of the following: drooling, pain, dysphagia, vomiting or stridor; evidence of oropharyngeal burns; a history of intentional ingestion of a substantial amount (e.g. > 50 mL of a concentrated preparation) of corrosive material.

Also in this study, the recommendation of TIC for ES was the ingestion of a larger amount of a corrosive and/or persistent symptom, however in practice ES was performed more often.

The results were that in 11 children (35.5 % of all performed ES) the ES was performed with normal finding.

Fortunately, the composition of cleaning products slowly evolves to less dangerous products.

At present, dishwasher powder and tablets contain disilicate that replaced metasilicate and silicate that were substantially more corrosive [42]. Lower corrosive effect can explain why about 78% of accidents due to dishwasher powder and tablets were symptomless.

Widely used cleaning products in the Czech Republic contain less than 5% sodium hypochlorite. Since they have only irritating properties at the lower than 10% concentration used in household products, they usually cause only nausea and vomiting due to mucosal irritation. This group of products contains even less than 1% of NaOH. This product is corrosive (strongly alkaline). Exposure to any quantity could be dangerous [41]. However, this study showed that the difficulties in connection with the accidental ingestion were minor or rather absent. But in the case of intentional ingestion of higher doses – about 8 sips (i.e. suicide) the ES showed damage of the oral cavity, grade 1 and symptoms were in all suicide cases.

The descalers were frequent in the inquiries; however the severity of ingestions was very low. Nowadays mostly organic acids, that are less corrosive, were used; in addition their buffering reaction with calcium from the limescale and the food occurs [25]. In this study, all subjects consumed the descaler solution as a tea, coffee or milk drink. The product has never been ingested as a concentrated product. A mild acid aftertaste probably warns the people and prevents ingestion of a large amount.

The MSDS can be extremely valuable in helping the emergency physician ascertain the potential toxicity of a given hazardous chemical substance. Emergency physicians should be aware of the existence of MSDS documents and be familiar with their format and the information available on them [43]. Unfortunately, the label of the product may not contain the full information and MSDS must be searched and compared.

This is not exclusively a problem of Czech products, as many cleaning products are imported from the EU countries. EAPCCT Guidelines have been developed for the completion of the product information form and endorsed by the EAPCCT Board on September 18, 2010 [44]. In addition, the total reserve acidity/alkalinity of the product, where appropriate, would be useful, as a much more precise parameter of corrosive effect, than pH [3].

For an adequate risk assessment in case of intoxications with a cleaning product, detailed information on the composition is necessary. Relevant information should be provided according to the Regulation 1907/2006 on the Safety Data Sheet [44].

Cleaning products pose a difficult problem in poisoning because of the lack of data in the humans and differing exposure conditions. Frequently, the only information available is the trade name of the product and additional information can be found only in the poison centers. In most instances it is possible to make an educated guess of the expected toxicity on the basic of the nature of the products [45]. However, the uncertainty may lead to unnecessary health care including relatively invasive examinations in young children, such as ES. Both the TIC specialists and pediatricians must consider the worst scenario that could come into question.

### *4.1. Application of pH for cleaning product characterization*

Applicability of pH determination for getting of comparable parameters was tested on common commercial descalers used in the Czech Republic. The determination of pH was complicated by the fact that some pigments (days) are added to the cleaning products. Therefore the pH determination cannot be realized using pH indicator papers, which change their colors in dependence on the acidity (basicity) of the products. Electrochemical determination had to be realized by the electrode, which enables the measurements in alkaline solutions (the theoretical pH of some extremely alkaline solutions should amount to about 13).

As it follows from the results summarized in Tab. 4, the hot drinks prepared from solutions exhibited much lower pH (approximately about 3), than those prepared from drinking water only (approximately about 7). Nevertheless, in correspondence with results registered by Czech TIC as well as mentioned literature [3, 25, 46, 47], the consequences are not danger for human health. One of possible explanation consists in the fact that the tea-kettles, their heating elements were slightly covered by limescale at the start of our experiments. Therefore we can suppose that relatively small parts of agents were neutralized by limescale compound. Simultaneously, the achieved pH-values are relatively safe. pH-value 3.0 of a drink is medically important as corrosive damage can be expected below this value [25]. The other important limits represent pH-values 4.5, 6.5, and the neutral value 7.0 (original pH of used drinking water) [48]. pH-value of drinking water must be kept within 6.5 - 9.5 in the Czech Republic (CR); pH of packed drinking water and water in containers [48] must be higher than 4.5. For comparison, pH values of different beers amount to 3.5-5.0, colas are in range of 2.0-3.0 [25].

Moreover, the result achieved in measurements of pH values of these products does not correspond with the objective findings. Therefore, we investigated TAR of four different cleaning products, used for limescale removing. The amounts of NaOH necessary for achievements of chosen pH 3.0 (literature limit of safety), 4.5 (pH of common drinking water), 6.0 (usual pH value of drinking water) and 7.0 (neutral solution) values in 100 mL of the descalers are depicted in Fig. 4. It is clear that the amounts of sodium hydroxide differ in case of different products. The smallest amount was necessary to add in the case of remover denoted A. Its TAR, which can be seen as the buffer capacity, was very low. From the toxicological point of view, it seems to be positive. Nevertheless, the real efficiency of this remover seems to be very low, because the amount of the limescale, which can be destroyed by it, is very low. This descaler was composed from diluted CA and tensides. The most danger, simultaneously, the mostly effective was ten times diluted remover D, containing ASA 5-15 %, OPA 5 % and tensides 2 %. The results achieved in these experiments are consistent with those published in [25].

The time factor was investigated too. From the results, summarized in Tab. 5, can be concluded, that pH slightly increased or stayed unchanged after preparation and boiling (from $\Delta$pH = 0 to about $\Delta$pH 0.8). In the following 15 hours pH (expressed in the form of TAR) did not change substantially. Generally, the decreases of TAR values from 0 to 12 % were recorded. The maximal decrease of TAR was observed in the case of descaler D (5-15 % of ASA, 5 % of OPA, and 2 % of tensides).

## 5. CONCLUSION

Acute exposure to cleaning products in children and adults constitutes a major problem for healthcare specialists worldwide [49, 50]. This injury occurs mostly by accident, and the accidental ingestion of cleaning products instead of a soft drink or water is very common [51]. Careless storage and improper safeguarding of chemical is the single reason for accidental ingestion. Consecutively, caretakers' education about intoxication prevention seems necessary.

Labeling of cleaning products plays an important role in the prevention and treatment of exposure, since the label should be a source of toxicological information and instructions to first aid for parents and adults and health professionals [52]. It is important to note, that just because a package does not have a warning label doesn't mean it is safe. It is necessary to achieve the situation when the label of any cleaning products should show the content and precise percentage of all hazardous substances.

For characterization of the dangerousness represented by descalers the determinations of their pH values was suggested. However, the higher explanatory power exhibited their TAR, which can be seen as their buffer capacity, i.e., amount of the alkaline solution, which is necessary to add to the cleaner solution to reach the chosen (safe) values. The relatively low TAR values, which are necessary for reaching of safe limit of pH (about 3) in case of investigated cleaners, consumption of descalers for limescale removing sediment from the walls and from the heating coil, and mild acid aftertaste probably can explain the fact that the reported severities of ingestions have been very low.

ACKNOWLEDGEMENTS
The authors would like to thank for the support by the project MSM 0021620807 and by the project GA AV IAA400400806.

## References

1. A. F. Sawalha, *Accident Analysis and Prevention,* 39 (2007) 1186
2. D. Pelclova and T. Navratil, *Toxicol Rev,* 24 (2005) 125
3. R. S. Hoffman, M. A. Howland, H. N. Kamerow, and L. R. Goldfrank, *Journal of Toxicology-Clinical Toxicology,* 27 (1989) 241
4. A. Chibisev, *Medicinski Arhiv,* 64 (2010) 320
5. A. Chibishev, Z. Pereska, V. Chibisheva, C. Bozinovska, N. Simonovska, and I. Jurukov, *Clinical Toxicology,* 49 (2011) 243
6. V. Adam, I. Fabrik, V. Kohoutkova, P. Babula, J. Hubalek, R. Vrba, L. Trnkova, and R. Kizek, *International Journal of Electrochemical Science,* 5 (2010) 429
7. D. Huska, O. Zitka, O. Krystofova, V. Adam, P. Babula, J. Zehnalek, K. Bartusek, M. Beklova, L. Havel, and R. Kizek, *International Journal of Electrochemical Science,* 5 (2010) 1535
8. P. Majzlik, A. Strasky, V. Adam, M. Nemec, L. Trnkova, J. Zehnalek, J. Hubalek, I. Provaznik, and R. Kizek, *International Journal of Electrochemical Science,* 6 (2011) 2171
9. O. Zitka, H. Skutkova, O. Krystofova, P. Sobrova, V. Adam, J. Zehnalek, L. Havel, M. Beklova, J. Hubalek, I. Provaznik, and R. Kizek, *International Journal of Electrochemical Science,* 6 (2011) 1367
10. J. Fischer, L. Vanourkova, A. Danhel, V. Vyskocil, K. Cizek, J. Barek, K. Peckova, B. Yosypchuk, and T. Navratil, *International Journal of Electrochemical Science,* 2 (2007) 226
11. T. Navratil, S. Sebkova, and M. Kopanica, *Analytical and Bioanalytical Chemistry,* 379 (2004) 294
12. T. Navratil, *Current Organic Chemistry,* 15 (2011) 2996
13. T. Navratil, *Current Organic Chemistry,* 15 (2011) 2921
14. S. Sebkova, T. Navratil, and M. Kopanica, *Analytical Letters,* 38 (2005) 1747
15. L. Vankova, L. Maixnerova, K. Cizek, J. Fischer, J. Barek, T. Navratil, and B. Yosypchuk, *Chemicke Listy,* 100 (2006) 1105
16. K. Peckova, J. Barek, T. Navratil, B. Yosypchuk, and J. Zima, *Analytical Letters,* 42 (2009) 2339
17. Z. Dlaskova, T. Navratil, M. Heyrovsky, D. Pelclova, and L. Novotny, *Analytical and Bioanalytical Chemistry,* 375 (2003) 164
18. T. Navratil and J. Barek, *Critical Reviews in Analytical Chemistry,* 39 (2009) 131
19. O. Zitka, D. Huska, V. Adam, A. Horna, M. Beklova, Z. Svobodova, and R. Kizek, *International Journal of Electrochemical Science,* 5 (2010) 1082
20. B. Yosypchuk, T. Navratil, A. N. Lukina, K. Peckova, and J. Barek, *Chemia Analityczna (Warsaw),* 52 (2007) 897
21. M. M. Antonijevic, S. C. Alagic, M. B. Petrovic, M. B. Radovanovic, and A. T. Stamenkovic, *International Journal of Electrochemical Science,* 4 (2009) 516
22. M. M. Antonijevic, G. D. Bogdanovic, M. B. Radovanovic, M. B. Petrovic, and A. T. Stamenkovic,

*International Journal of Electrochemical Science*, 4 (2009) 654
23. M. M. Antonijevic, S. M. Milic, M. D. Dimitrijevic, M. B. Petrovic, M. B. Radovanovic, and A. T. Stamenkovic, *International Journal of Electrochemical Science,* 4 (2009) 962
24. M. M. Antonijevic, S. M. Milic, M. B. Radovanovic, M. B. Petrovic, and A. T. Stamenkovic, *International Journal of Electrochemical Science*, 4 (2009) 1719
25. T. Navratil, B. Ricarova, Z. Senholdova, H. Rakovcova, and D. Pelclova, *Chemicke Listy,* 101 (2007) s138
26. G. B. Boldt and R. G. Carroll, *American Journal of Emergency Medicine*, 14 (1996) 106
27. H. B. T. Christesen, *Clinical Otolaryngology,* 20 (1995) 272
28. C. Ertekin, O. Alimoglu, H. Akyildiz, R. Guloglu, and K. Taviloglu, *Hepato-Gastroenterology,* 51 (2004) 1397
29. in *Decree of Ministry of Agriculture of the Czech Republic*, Vol. No. 146/2004 Coll. of Law (2004), p. 1979
30. H. E. Persson, G. K. Sjoberg, J. A. Haines, and J. P. de Garbino, *Journal of Toxicology-Clinical Toxicology,* 36 (1998) 205
31. EAPCCT,*European Association of Poisons Centres and Clinical Toxicologists*, http://www.eapcct.org/ (30.5.2011 2011)
32. T. M. J. Beirens, E. F. van Beeck, R. Dekker, J. Brug, and H. Raat, *Accident Analysis and Prevention,* 38 (2006) 772
33. S. Assar, S. Hatami, E. Lak, M. Pipelzadeh, and M. Joorabian, *Pakistan Journal of Medical Sciences,* 25 (2009) 51
34. F. Valent, G. Messi, L. Deroma, C. De Marchi, S. Norbedo, and A. G. Marchi, *European Journal of Pediatrics,* 166 (2007) 949
35. M. Bryan, UTMB, Grand Rounds (1995)
36. H. T. Cheng, C. L. Cheng, C. H. Lin, J. H. Tang, Y. Y. Chu, N. J. Liu, and P. C. Chen, *Bmc Gastroenterology,* 8 (2008)
37. J. Broto, M. Asensio, C. S. Jorro, C. Marhuenda, J. M. G. Vernet, D. Acosta, and J. B. Ochoa, *Pediatric Surgery International*, 15 (1999) 323
38. D. Baskin, N. Urganci, L. Abbasoglu, C. Alkim, M. Yalcin, C. Karadag, and N. Sever, *Pediatric Surgery International*, 20 (2004) 824
39. U. Bicakci, B. Tander, G. Deveci, R. Rizalar, E. Ariturk, and F. Bernay, *Pediatric Surgery International*, 26 (2010) 251
40. P. Janousek, M. Jurovcik, P. Grabec, and Z. Kabelka, *International Journal of Pediatric Otorhinolaryngology,* 69 (2005) 1429
41. Toxbase,*Ingestion of the corrosive material*, http://www.toxbase.org/ (5.5.2011 2011)
42. A. Bertinelli, J. Hamill, M. Mahadevan, and F. Miles, *Journal of Paediatrics and Child Health,* 42 (2006) 129
43. M. I. Greenberg, D. C. Cone, and J. R. Roberts, *Annals of Emergency Medicine,* 27 (1996) 347
44. European_Commision, in *Stakeholder workshop report*, Publications Office of the European Union, Brussels (2010), p. 48
45. T. Y. Chan, K. P. Leung, and J. A. Critchley, *Singapore Med J,* 36 (1995) 285
46. B. Ricarova, I. Kotasova, Z. Senholdova, D. Pelclova, H. Rakovcova, and T. Navratil, *Clinical Toxicology,* 44 (2006) 573
47. Z. Senholdova, T. Navratil, B. Ricarova, and H. Rakovcova, in *XXVII. Modern Electrochemical Methods* (J. Barek and T. Navratil, eds.), Czech Chemical Society, Jetrichovice (2007), p. 149
48. in *Decree of Ministry of Health of the Czech Republic*, Vol. No. 252/2004 Coll. of Laws (2004), p. 5402
49. N. Manzar, S. M. A. Saad, B. Manzar, and S. S. Fatima, *Bmc Pediatrics,* 10 (2010)
50. M. Lifshitz and V. Gavrilov, *Israel Medical Association Journal,* 2 (2000) 504
51. B. Celik, A. Nadir, E. Sahin, and M. Kaptanoglu, *Diseases of the Esophagus,* 22 (2009) 638

52. R. d. F. Presgrave, E. N. Alves, L. A. B. Camacho, and M. H. S. V. Boas, *Ciencia & Saude Coletiva*, 13 (2008) 683