Biochemical indicators of caustic ingestion and/or accompanying esophageal injury in children

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A prospective clinical study was conducted to evaluate whether or not any biochemical predictor of caustic ingestion and complicating esophageal injury exists. Children who were admitted to the hospital within 24 hours following caustic substance ingestion between 1994 and 2000 inclusive were evaluated. The ingested substance and complaints upon admission were noted. Groups were constructed according to the ingested substances such as household bleach (HB) (Group 1), acid (Group 2) or alkali ingestion (Group 3). Full biochemical analyses, chest X-ray and blood gas estimations were obtained and children were evaluated endoscopically.

Seventy-eight children were studied. There were 19, 20 and 39 children in Groups 1, 2, and 3, respectively. There were no sex or age differences among groups (p>0.05). Esophagogastric injury was not encountered in Group 1. Second degree injury was present in 12 and 11 children in Group 2 and Group 3, respectively. Blood pH level was decreased in Group 1 (p=0.013), but not different in Groups 2 and 3 (p>0.05). pH did not differ in patients with or without esophageal injury (p>0.05). While serum uric acid values were significantly increased in children with esophageal burn (p=0.001), serum phosphorus and alkaline phosphatase levels were significantly decreased in children with esophageal injury (p=0.01 and p=0.019, respectively). Blood bicarbonate and serum potassium, chloride, urea nitrogen, creatinine, glutamic-oxaloacetic transaminase, glutamic-pyruvic transaminase, lactic dehydrogenase, calcium, glucose, protein, albumin and bilirubin levels did not differ between group (p>0.05), nor between patients with or without complicating esophageal injury (p=0.05).

Low serum pH level is an indicator of HB ingestion. Routine endoscopy may not be necessary in children with normal blood pH values after ingestion. Although normal values of pH, uric acid, phosphorus and alkaline phosphatase levels do not rule out ingestion of an acid-or alkali-containing substance other than HB, increase in uric acid and decreases in phosphorus and alkaline phosphatase levels point to the presence of an esophageal injury.

Key words: caustic, children, corrosive, injury, ingestion.

Accidental caustic ingestion is one of the common problems worldwide among children. Since the presence of an esophageal injury cannot be predicted through signs and symptoms, the suspicion of any ingestion is accepted to mandate an esophageal evaluation. In some cases, the ingestion is not witnessed, and evaluations based on suspicion may sometimes be unnecessary.

On the other hand, the biochemical alterations that follow caustic ingestion have not been thoroughly evaluated in the literature. Therefore a prospective clinical study was planned to evaluate if any biochemical predictors of caustic ingestion and complicating esophageal injury exist.

Material and Methods

The children admitted with definite caustic ingestion between 1994 and 2000 inclusive were evaluated prospectively. Patients without metabolic, hepatic or renal disease and who were admitted within 24 hours following ingestion were enrolled into the study. All

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patients and/or their parents were questioned about the type of ingested substance and complaints. Physical examination was performed. Chest X-ray was obtained, and blood samples were withdrawn for blood gas estimations and biochemical analyses including sodium, potassium, chloride, urea nitrogen, creatinine, glutamic-oxaloacetic transaminase (SGOT), glutamic-pyruvic transaminase (SGPT), lactic dehydrogenase (LDH), alkaline phosphatase (ALP), calcium, phosphorus, glucose, protein, albumin, uric acid and bilirubin (total and conjugated) determinations.

All patients underwent fiberoptic esophagogastroscopic examination (FEG) (Olympus GIF type XP or Pentax FG-29V) by one of the senior pediatric surgeons within 48 hours after admission. The status of the esophagus, stomach and pylorus was evaluated. If a burn was encountered, the localization, degree and The patients were grouped according to the ingested substances. Group 1 patients ingested chlorine bleach, Group 2 patients ingested acid substances, and Group 3 patients ingested alkali caustics. The presence or absence of caustic injury according to FEG findings was determined within groups.

For evaluating the alterations in blood gas and biochemical parameters, the values were compared with reference values (Table I). Results of blood gas evaluations and biochemical evaluations according to the groups were compared. The values were also compared according to the presence or absence of caustic injuries within the groups.

Data were expressed as mean \pm SD, and analyzed using SPSS statistical program. Chi-square test and one way analysis of variance (ANOVA) statistics were used for comparison. P value lower than 0.05 was considered to be significant.

Parameter	Normal ranges
pH	7.35-7.45
Bicarbonate	Arterial: 19-24 mEq/L
	Venous: 22-26 mEq/L
Sodium	138-145 mEq/L
Potassium	3.4-4.7 mEq/L
Chloride	95-110 mEq/L
Blood urea nitrogen	5-18 mg/dl
Creatinine	0-1.3 mg/dl
Glutamic-oxaloacetic transaminase	0-37 U/L
Glutamic-pyruvic transaminase	0-41 U/L
Lactic dehydrogenase	240-480 U/L
Alkaline phosphatase	250-1000 U/L
Calcium	8.8-10.8 mg/dl
Phosphorus	2.7-4.5 mg/dl
Glucose	60-100 mg/dl
Protein	6.6-8.7 g/dl
Albumin	3.5-5 g/dl
Uric acid	2.4-5.7 mg/dl
Bilirubin-total	0.1-1.2 mg/dl
Bilirubin-conjugated or direct	0-0.4 mg/dl

Table I. Biochemical and Blood Gas Parameters and Reference Values

extension were noted. Edema and hyperemia of the esophagus were accepted to represent a 1st degree burn. While the ulcerations in the esophagus were accepted to represent a 2nd degree burn, X-ray findings of esophageal perforation were accepted to represent a 3rd degree burn. Second-degree burn patients underwent a treatment protocol that included steroid, antibiotics and early bougienage (SAEB)^{1,2}.

Results

Seventy-eight children were evaluated during the study period. There were 45 boys (58%) and 33 girls (42%). The mean age was 3.6 ± 2.8 years (range: 2 months to 15 years). There was no sex or age difference between the groups (p>0.05).

The contents of ingested materials are shown in Table II. No esophagogastric injury was

	Ingested material	Contents	Endoscopic findings
Group 1	Household bleach	Sodium hypochlorite (1-5%) + sodium hydroxide (0.01-0.02%) mixture (n:19)	No injury
Group 2	Acid-containing substances	Hydrochloric acid (n:13), potassium permanganate (n:3), acetic acid (n:2), nitric acid (n:1), sulfuric acid (n:1)	2 nd degree injury (n: 12)
Group 3	Alkali-containing substances	Sodium hydroxide (n:35), hydrogen peroxide (n:3), potassium hydroxide (n:1)	2 nd degree injury (n: 11)

Table II. Types and Contents of Caustic Substance and Results of Endoscopic Examination

encountered in Group 1 patients at FEG. Seconddegree esophageal injury was present in 12 and 11 children in Groups 2 and 3, respectively.

Blood pH level was significantly decreased in Group 1 (p=0.013), but there was no significant difference in Groups 2 and 3 (p>0.05). Blood pH values did not differ in patients either with or without a caustic esophageal injury (p>0.05). Blood bicarbonate level did not show any significant difference between groups, and it was not altered according to presence or absence of injury (p>0.05).

Serum sodium values were increased in Group 3 patients but this increase was of low significance (p=0.056). The presence of esophageal injury did not result in any difference among serum sodium values (p>0.05).

Serum uric acid values were significantly increased in children with esophageal injury resulting from either acid or alkali substances (p=0.001). This finding was especially pertinent for esophageal injury due to alkali substance ingestion (p=0.003).

Serum phosphorus and ALP levels were significantly decreased in children with esophageal injury (p=0.01 and p=0.019, respectively). The decrease was independent of the acid or alkali nature of the caustic substance (p>0.05).

Serum potassium, chloride, urea nitrogen, creatinine, SGOT, SGPT, LDH, calcium, glucose, protein, albumin and bilirubin levels did not differ between groups (p>0.05), nor between patients in the same group who were with or without esophageal injury (p>0.05).

Discussion

Since many caustics are easily accessible by children, accidental caustic substance ingestion is a common worldwide problem.

Household bleaches (HB) that are weak alkalis containing 2-5% sodium hypochlorite and 0.01-0.02% sodium hydroxide are widely used at home^{3,4}. Parents sometimes do not witness the ingestion though they find their children playing with a bottle of HB. Nevertheless, those children undergo FEG depending on a suspicion of ingestion.

The present study has revealed a significant decrease in blood pH values after HB ingestion. The outcome of cases who ingested HB differs according to the pH of the medium. If the pH is below 2, chlorine gas is generated. Between the pH values of 2 and 7.5, the main species is hypochlorous acid. If the pH of the medium is above 7.5, hypochlorite ion is mainly produced 3,5,6 . Therefore, according to Henderson-Hasselbach equation, lower blood pH level indicates addition of an acid substance into the circulation following HB ingestion⁷. Hypernatremia and hyperchloremia in association with metabolic acidosis have been reported following ingestion of a large amount (500 ml) of bleach in an adult⁸. Increased sodium and chloride concentrations were also encountered due to large loads of those elements in this case. However, we did not encounter any alterations in serum sodium and chlorine levels in our study, possibly due to ingestion of smaller volumes of HB. The decrease in blood pH values in children admitted with either definite or suspected HB ingestion appears to indicate HB reached the stomach.

Although HB are traditionally considered among caustic substance, their caustic effects have been questioned^{3,4}. No esophageal or gastric injury was encountered after HB ingestion in the present series. Therefore the necessity of FEG in children admitted with HB ingestion should be reevaluated. Although it could not be definitively proven by the results of our study, children who

have normal blood pH values after suspected HB ingestion possibly have not ingested the substance. At least those children with normal pH values should be spared from FEG.

One of the important determinants of caustic effects of a substance is its acid or alkali nature. Although their caustic effects are well evaluated, their effect on acid-base balance in children has not been evaluated⁹⁻¹¹. Neither alkali nor acid ingestion altered the acid-base balance in the present series. This finding differs from the findings in adults who ingest large quantities to commit suicide¹². Since alkali or acid ingestion does not alter the acid-base balance, blood gas values have no role in predicting their ingestion.

While children with 2nd degree burns following either acid or alkali substance ingestion revealed an increase in serum uric acid levels, they contrarily revealed decreases in phosphorus and alkaline phosphatase levels. Uric acid is the end product of dietary and endogenous purine metabolism in humans. It is formed from the purines of tissue and dietary nucleoproteins and nucleotides. An increase in uric acid results from increased production or inefficient clearance. Increased production is usually due to increased destruction of nucleoproteins in conditions such as lymphoproliferative disorders, disseminated neoplasms and leukemia^{13,14}. Acutely damaged esophagogastric mucosa and/or deep layers may increase the cellular turnover and result in increased serum uric acid level following caustic injury. Approximately 75% of the daily urate production is excreted by the kidneys. The remainder is eliminated through the gastrointestinal tract via biliary, gastric, and intestinal secretions¹³. Since esophageal and/or gastric mucosa is destroyed by caustic substances, this may have resulted in a deficiency in the clearance of uric acid and caused an increase in the serum uric acid level. Additionally, hypovolemia due to disturbed oral fluid intake and loss of fluid through the burned surfaces in patients with caustic injury may have provoked a relative increase in serum uric acid concentrations.

Hypophosphatemia is known to result from intracellular shift of phosphate, increased loss via kidney or intestine, or decreased intestinal absorption^{12,14}. Acidosis induces a shift of phosphorus from intracellular to extracellular fluid and causes a rise in serum phosphate levels¹⁵. Adversely, alkalosis may be expected to cause hypophosphatemia. Since no pH change has been encountered in patients with caustic injury, this mechanism does not appear to work. Intravenous glucose administration causes a decrease in serum phosphorus levels¹⁶. Similarly, serum glucose levels did not differ between patients with or without caustic injury. Therefore, phosphorus appears to have decreased due to loss from injured alimentary tract and/ or inappropriate intake following caustic injury.

Alkaline phosphatase is an enzyme that works mainly in the liver and bones. Decrease of this enzyme is associated with an excess of vitamin D ingestion, milk-alkali syndrome, hypophosphatasia or malnutrition¹⁴. Thus, decrease in serum phosphorus levels may satisfactorily explain the mechanism of decrease in serum ALP levels following caustic injury. While the serum uric acid level appears to reflect the tissue damage, serum phosphorus and ALP levels appear to indirectly reflect the damage through limitation of oral intake in children who have had esophageal injuries following caustic ingestion.

On the other hand, serum electrolytes and other biochemical parameters including SGOT, SGPT, LDH, urea nitrogen, creatinine, calcium, glucose, protein, albumin and bilirubin do not appear to be indicative of a caustic substance ingestion and/or predictive of a caustic esophageal injury.

Low serum pH level indicates the ingestion of HB. Routine endoscopy may not be necessary in children with normal blood pH values after a history of suspicious ingestion. Although normal values of pH, uric acid, phosphorus and ALP levels do not rule out ingestion of an acid-or alkalicontaining substance other than HB, increase in uric acid and decreases in phosphorus and ALP levels point to the presence of an esophageal injury due to ingestion of a caustic substance.

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