Lecture 9: Caustics

What are Caustics Chemicals?

- Chemicals that cause tissue injury on contact with mucosal and epithelial surfaces.
  Include: -Alkaline -Acidic

Alkalis

Alkalis accept protons, resulting in the formation of conjugate acids and free hydroxide ions(donator).

-Turn Pink Litmus Blues (Litmus paper is a paper that has specific color and changes when it comes in contact with acid or alkaline)

-Lye is an example of an alkali and refers to both sodium hydroxide (NaOH) and potassium hydroxide (KOH).

-Ammonia (NH_3) is another common alkaline corrosive (How ammonia act as alkaline ? Ammonia will **accept H** ion and converts to ammonium NH_4)

Acids

Acids are proton donors, as they dissociate into conjugate bases and free hydrogen ions in solution.

Acidic caustics include :

-hydrochloric acid HCL (Common) found in **Rust Removal or Toilet bowl cleaner**

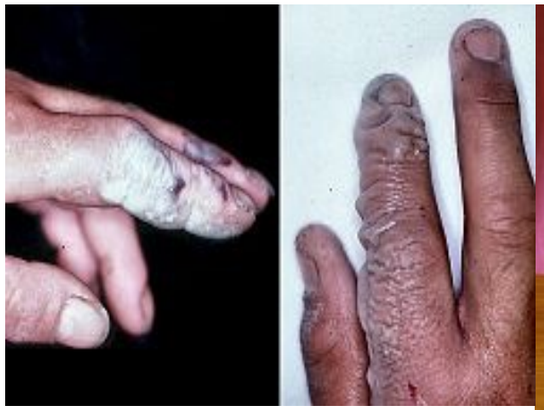
-sulfuric acid (H_2SO_4) acidic found in drain cleaners.

Perspective

The severity of caustic agents typically increases with a pH less than 3 or greater than 11.

3-11 is not strong beyond these is strong but there exception in

On the contrary, hydrofluoric acid (HF) is a relatively weak acid that can cause necrotizing injury and life-threatening systemic toxicity(caused by fluoride ion not because of it is acidity)



HF burns, not evident until a day after

Other Caustics:

Other chemicals that have caustic properties not because of if it is acid or alkali

Phenol

Formaldehyde

Iodine

concentrated hydrogen peroxide.

Common Caustics Products:

-Liquid drain cleaners have high concentrations of alkali (30% KOH) or acid (93% H_2SO_4).

-Industrial and farms (dairy pipeline) cleaners containing liquid NaOH and KOH (in concentrations of 8–25%)

-Swimming pool cleaners also contain caustics in high concentrations.

Note:
Large volume > large container > high conc.

Household Cleaning Products That Contain Caustic Chemicals

APPLICATION	PRODUCT (MANUFACTURER) CHEMICAL
Drain cleaner—liquid	Heavy Duty Liquid Drain Opener (Share), H_2SO_4 93% Drain Out Extra (Iron Out), KOH 30% Liquid-Plumr (Clorox), NaOH 0.5–2%, NaOCl 5–10% Maximum Strength Drain Opener (Enforcer), KOH 1–10%, NaOCl < 5% Drain Care Professional Strength Drain Opener, NaOH 5–15%
Drain cleaner—crystals	Heavy Duty Crystal Drain Opener (Roebic), NaOH 100% Crystal Drain Opener (Rohyme), NaOH 74%

Household Cleaning Products That Contain Caustic Chemicals

Oven cleaner	Easy Off Heavy Duty Oven Cleaner (Reckitt), NaOH 4–6%
Rust remover	Rust Remover/Carpet Care (Johnson Wax Prof), HCl 10% Rust Stain Remover (Whink), HF 2.5–3% Rust Stripper (Certified), NaOH 50–75% Naval Jelly Rust Remover (Loctite), Phosphoric acid 25–30%
Toilet bowl cleaner	Instant Power Toilet Bowl Cleaner (Scotch), HCl 26% Bowl and Porcelain Cleaner (Cleanline), HCl 0.10% Bowl/Tile/Porcelain Cleaner (Share), Phosphoric acid 15–25% Husky 303 Toilet Bowl Cleaner, HCl 23%

Accidental Versus Intentional Ingestion

- Intentional ingestions have a greater degree of oropharyngeal sparing due to rapid swallowing but have a higher likelihood of serious injury.
- More than half of suicidal patients who ingest caustic agents have a history of psychiatric illness.

Solid Versus Liquid Corrosives:

- Which one do you think cause more burn and why ?

Solid, because Crystals and solid particles have prolonged tissue adherence, causing more severe burns.

- Usually limited by immediate oral pain, causing them to be spit out sooner than a liquid agent.
- The ingestion of granular automatic dishwashing detergents is associated with devastating injuries

Solid Versus Liquid Ingestions

- -Crystal drain cleaners have lye concentration as high as 74% NaOH and may cause proximal esophageal injury.
- -Liquid household bleach typically contains dilute (5.25%) sodium hypochlorite (NaHClO), and ingestion rarely causes injury.
- -Industrial-strength bleach may contain significantly higher concentrations of NaHClO,
- Toilet bowl cleaners contain hydrochloric acid as high as 26%
- -Anticorrosive cleaners, such as 31% muriatic acid (HCl), are sold in gallon containers for home use and as swimming pool cleaners.

Factors that influence the extent of injury

- Type of agent (Acid/Alkali)
- Solid/Liquid
- Concentration of solution (large Volume > high concentration)
- Viscosity (gel as compared to liquid has bigger contact with mucosa and cause deeper burn)
- Duration of contact
- pH (<3 or > 11more harmful)
- Presence or absence of food in the stomach (present of food in stomach cause diluted of what ever is ingested which is protective)

Mechanism of Injury: Acids

- Acidic compounds desiccate epithelial cells and cause coagulation necrosis
- An eschar is formed thereby limiting further penetration(Protective) less chance of perforation.
- Acids tend to have a strong odor and cause immediate pain on contact, the quantity ingested is usually small
- Because of resistance of squamous epithelium to coagulation necrosis, acids are thought to be less likely to cause esophageal and pharyngeal injury
- Acids can be absorbed systemically, **causing metabolic acidosis**, as well as damage to the spleen, liver, biliary tract, pancreas, and kidneys.

Acid are relatively less effective on harming squamous epithelium (skin , oral mucosa , pharynx)

What is the acidity of the saliva ? Alkline

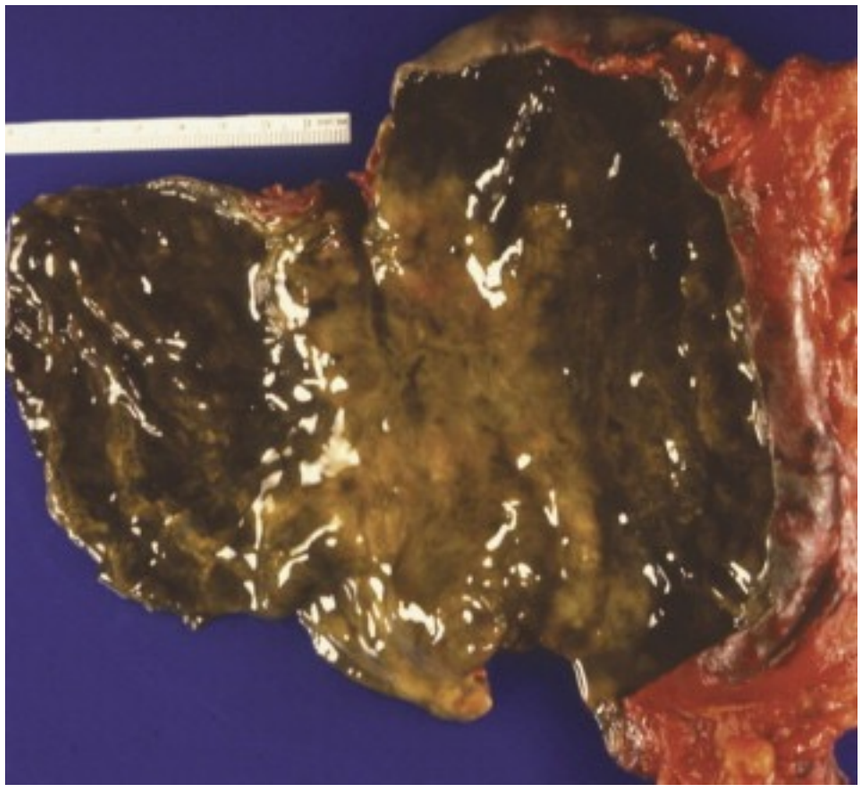
What is the acidity of the stomach ? Acid

So if an acid is ingested the alkali of the saliva is going to neutralize burn there but if it goes down to stomach it will an additive effect which cause more burn .

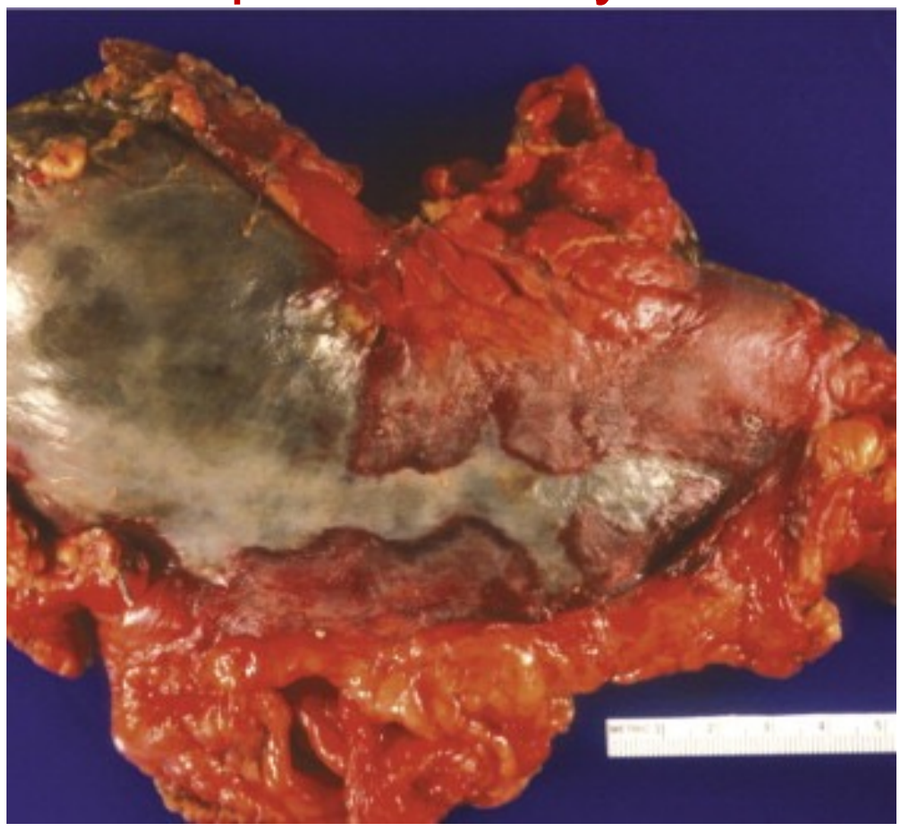
Mechanism of Injury: Alkalis

- Alkaline contact causes liquefaction necrosis, fat saponification, and protein disruption, allowing further penetration of the alkali
- The depth of the necrosis depends on the concentration of the alkali
- A concentration of 30% NaOH in contact with tissue for 1 second results in a full-thickness burn.
- Alkalis are colorless, odorless, and unlike acids, do not cause immediate pain on contact.
- Alkaline ingestions typically involve the squamous epithelial cells of the oropharynx, hypopharynx, and esophagus.
- The narrow portions of the esophagus, where pooling of secretions can occur, are also commonly involved.
- Alkalis may also cause gastric necrosis and perforation.
- The esophagus can also be injured. Burns below the pylorus carry a worse prognosis than burns above the pyloris (50% vs. 9% mortality).
    - The extend of the burn in term of location : in endoscope if burn is seen beyond pylorus = cause 50% mortality

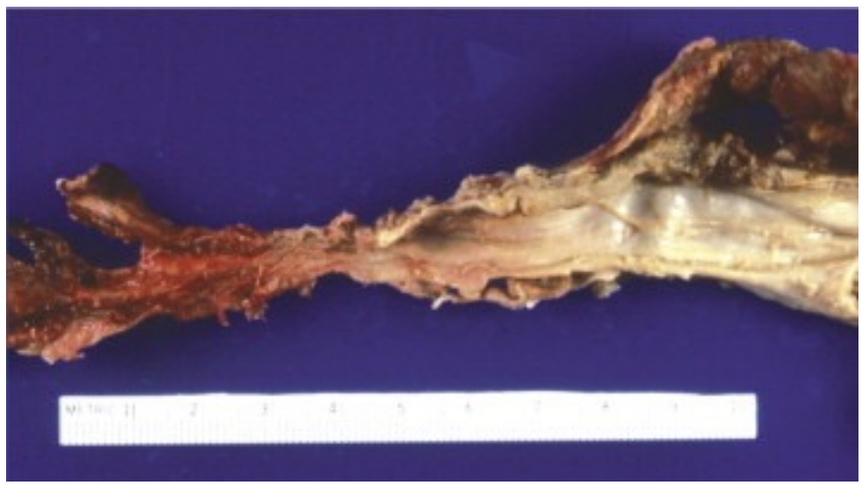
Gastric mucosa after ingestion of 35% potassium hydroxide



Gastric serosa after ingestion of 35% potassium hydroxide.



Esophagus after ingestion of 35% potassium hydroxide.



Stages of Caustic Injury

- Classically, the damage occurs in following steps.
- Necrosis (either coagulation or liquefaction)
  - invasion by bacteria and polymorphonuclear leukocytes.
  - Vascular thrombosis follows, increasing the damage.
    - Over the next 2 to 5 days, superficial layers of tissue begin to slough.
  - Healing: The tensile strength of the healing tissue may be quite low for up to 3 weeks increasing chance of delayed perforation
  - Between 1 week and several months, granulation tissue forms, collagen is deposited, and re-epithelization
- Esophageal stricture may form over a period of weeks to years from contraction of the scar.

- There is a period in which there is just necrosis but deeper walls are still intact , with time of inflammation and breakdown the wall becomes much weaker so chances of perforation at these stage is higher

Degree of Burn(severity):

- Caustic injury is graded into 3 degrees/Grades based on endoscopy
  - First: edema and hyperemia
  - Second: superficial ulcers, white membrane, exudates, friability and hemorrhage
    - Grade 2A: non circumferential (Partial)
    - Grade 2B: Circumferential (more chance of obstruction because it involved whole cicumfercne as compared to grade 2A)
  - Third: Transmural involvement with deep injury, necrotic mucosa, or frank perforation of the stomach or esophagus.
- The initial grade of burn on **esophagoscopy** correlates with the risk of stricture formation.

Chances of stricture Formation

-Grade 2A Burns: 15 to 30% develop strictures

-Grade 2B: upto 75% develop strictures

-Grade 3: 90% result in stricture

-Whether heat from the exothermic reaction increases the injury has never been quantified, but it has led to concerns regarding initial dilution or gastric lavage.(this happen when acid is ingested with alkali so never neutralize)

CLINICAL FEATURES(General):

-Airway edema and esophageal/gastric perforation are most emergent issues

-Laryngeal edema occurs over a matter of minutes to hours.

-Systemic toxicity; hypovolemic shock; and hemodynamic instability with hypotension, tachycardia, fever, and acidosis are ominous findings.

-Small ingestion of potent substances can be as serious as larger ingestions.

-More than 40% of patients reporting to have “only taken a lick” have esophageal burns.

-Patients present with oral pain (41%), abdominal pain (34%), vomiting (19%), and drooling (19%).

-Some have wheezing and coughing. Others present with stridor and dysphonia.

-Chest pain is common.

-Visible burns to the face, lips & oral cavity. Burns can occur from spills or contamination after vomiting

-Peritoneal signs suggest hollow viscous perforation or extension of the burn to adjoining visceral areas.

CLINICAL FEATURES

-Tracheal necrosis is one of the most frequent causes of death after caustic ingestion.

-Oropharyngeal burns alone do not appear predictive of more distal injury

Prolonged drooling and dysphagia predicted significant lesions with 100% sensitivity and 90% specificity.

Vomiting and stridor may also be more predictive of burn injury.

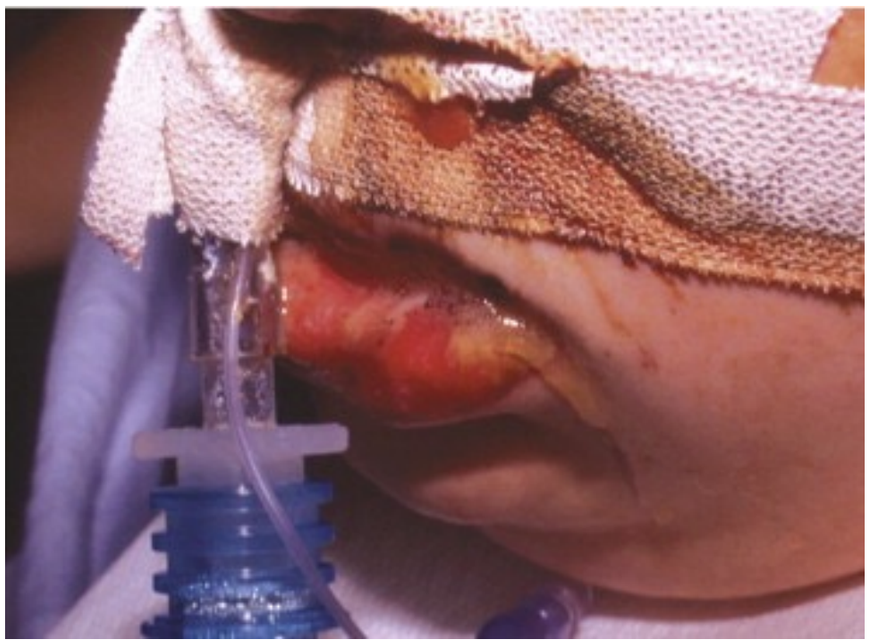
-Dysphagia usually subsides in 3 to 4 days.

-Patients with significant esophageal burns, particularly those that are circumferential, may develop esophageal stricture

-80% of strictures become apparent in 2 to 8 weeks.

-Symptoms include dysphagia and food impaction..

Lip burn after exposure to35% potassium hydroxide.



CLINICAL FEATURES

-Patients have an increase in esophageal cancer (1000-fold to 3000-fold increases) that develops 40 to 50 years after the caustic ingestion.

-A recent long-term study showed that 1.8% of patients who ingested caustic soda developed esophageal cancer.

-Nearly 3% of esophageal cancer patients have a history of caustic ingestion

-Significant acid ingestions may be devastating and result in a higher mortality rate than alkali ingestions.

-The fulminant course of some acid ingestions may be due to systemic absorption of the acid, resulting in metabolic acidosis (which may also be the result of extensive tissue necrosis), hemolysis, and renal failure.

DIAGNOSTIC STRATEGIES:

-Patients with chest and abdominal pain should have a chest radiograph and decubitus or upright abdominal studies to identify peritoneal and mediastinal air, denoting perforation or pleural effusion.

-Any suggestion of abdominal involvement should prompt abdominal CT or US.

-ABG to monitor systemic metabolic acidosis.

-In cases of intentional overdose, co-ingestants should be considered.

-Patients with S&S (vomiting, drooling, stridor, or dyspnea) should **undergo endoscopy within 12 to 24 hours** to define the extent of burn.

-Endoscopy is contraindicated in patients with possible or known perforation

-The finding of frank necrosis or obliteration of the lumen should result in termination of the procedure

-Endoscopy performed too early may miss the extent or depth of tissue injury.

-Hypoxia warrant immediate bronchoscopy

MANAGEMENT

-In alert patients who are not vomiting and can tolerate liquids, small volumes (1–2 cups) of water or milk can be considered within the first few minutes after ingestion .

-Forcing fluids is never indicated

-Do not neutralize the ingested corrosive with weak acids or alkalis due to thermal reactions and worsening injury

-Early and continuous respiratory and hemodynamic monitoring is essential.

-Contaminated clothing should be treated as hazardous waste and disposed of using proper precautions

-Activated charcoal, and performing gastric lavage are not indicated.

-Careful nasogastric aspiration may be useful in the setting of significant acid ingestions presenting immediately after ingestion

-Early endotracheal intubation is warranted with airway compromise suggested by hoarseness, throat pain, drooling, or edema.

-Intubation should be undertaken early before edema and secretions threaten the airway and make intubation difficult

- No Blind nasotracheal intubation
- When oral intubation is anticipated to be difficult awake fiberoptic intubation or primary surgical cricothyrotomy may be necessary

-IV access and vigorous fluid resuscitation

-Surgical exploration is indicated for free air, peritonitis, increasing and severe chest and abdominal pain, and hypotension.

-Corticosteroid therapy remains controversial.

-Prophylactic antibiotics may potentially mask evidence of impending perforation

SPECIAL CASES

Ocular alkali exposures are true ophthalmologic emergencies.

- Immediate and aggressive lavage with at least 2 L of normal saline per eye is indicated in all cases except for frank perforation

Dermal caustic exposures can also result in significant burn injuries. Clothing removal, copious irrigation, and local wound debridement are the most important initial treatment.

Hydrofluoric acid: Although a relatively weak acid the dissociated fluoride anions are problematic because of extreme electro-negativity

- Deaths from HF exposure have occurred after ingestion, after skin contact in areas as small as 1% BSA with concentrated HF & inhalation of HF vapor
- Systemic toxicity is characterized by immediate and profound hypocalcemia and dysrhythmias
- Cardiac and serum calcium monitoring are warranted in all

Povidone-iodine (Betadine): is used as a surgical scrub and is not a caustic agent, but ingestion of tincture of iodine can cause severe gastrointestinal injury and is potentially life-threatening.

- Gastric irrigation with starch or milk in these cases may convert iodine to less toxic iodide.

Phenol or Formaldehyde can also cause severe caustic injury to the gastrointestinal tract

- Both phenol and formaldehyde are general protoplasmic poisons and can cause protein denaturation and coagulation necrosis.

SPECIAL CASES

- Systemic symptoms, including dysrhythmias, hypotension, seizures, and coma, may result from phenol ingestion.
- Acidosis may be prominent after formaldehyde ingestion due to its metabolism to formic acid
- Phenol is well absorbed through the skin, dermal exposure may result in systemic toxicity
- Dermal decontamination of phenol exposures with LMW polyethylene glycol has been suggested but water may prove just as useful

Concentrated hydrogen peroxide (H_2O_2)

Ingestion may cause gastrointestinal burn injury and the formation of gas emboli

- Radiographic evaluation for the presence of gas in the chest or abdominal cavities, including the portal system, should be performed in symptomatic patients
- Hyperbaric oxygen has been used successfully to treat gas emboli from H_2O_2ingestion.

Button batteries are usually made of a metallic salt (lithium, mercury, nickel, zinc, cadmium, or silver) bathed in NaOH or KOH.

- Obstruction can cause pressure necrosis, caustic injury due to leakage of alkaline medium, or electrical injury.
- Ulceration, perforation, and possible fistula formation occur but are uncommon.
- Heavy-metal toxicity in this setting has not been reported
- Evaluation of button battery ingestions requires radiography to assess the position of the foreign body.
- Batteries lodged in the airway or esophagus require expeditious removal.
- Gastric or intestinal batteries can be treated with watchful waiting.
- Follow-up radiographs should be obtainedin 1 week if the battery has not passed.


Button batteries

KEY CONCEPTS

- Ingestion of very small amounts of a caustic material (even a lick) can cause serious esophageal injury.
- All symptomatic patients should undergo endoscopy and be considered for admission.
- Asymptomatic patients can undergo endoscopy in the emergency department or be discharged with very close follow-up monitoring.
- Caustic ingestions can lead to esophageal stricture and a lifelong increased risk of esophageal cancer.

Q1:A 10 year old child is brought to the hospital after ingestion of some poison. He is conscious and dynamically stable, but complains of sever oral pain and inability to swallow. On examination, he has swollen lips, tongue, and drooling of saliva.

Which of the following is the likely cause of this presentation?

a. Caustics
b. Paracetamol
c. Aspirin
d. Pesticides

Q2:A 8 year old child ingest drain cleaners and upper GI endoscopy has been performed.

What is the type of necrosis to be seen in the above patient?

a. Fibrinous
b. Liquifactive
c. Coagulative
d. Caseuos

Q3: Most lye solutions used as all purposed cleaners and for industrial purposes contain which one of the following?

a. Alkaline substance
b. Acidic solutions
c. Neutral pH solution
d. Mixture of acidic and alkaline solution

Q4: Which one of the following is an acid Caustic ?

A.Sodium hydroxide
B.Potassium hydroxide
C.Sulfuric acid
D.Ammonia

Answers : 1(A) – 2(C) – 3(A) – 4(C)

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