Managing of eye burns
Return to normal intraocular pH
First Aid
Experimental and clinical results

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Young lady with a privat accident: Burn with NaOH
First aid: saline soaked cotton and sent to the Dept. of Ophthalmology

We as professionals should prevent such cases
• Type of burns
• Mechanism of burns
• Dusts and Solid burns
• Burns with fluids
• Rinsing therapy
• Buffer or water ?
• Do and do not !
Zones of damage

Endothelium

necrosis

alteration

Healthy stroma
Affection of intraocular structures as a function of type of agent, concentration exposure time and temperature

Experimental NaOH-burns of rabbit corneas being exposed 20 seconds
What to do?
Rinse!!
Remove, dilute !!!
decontaminate !!
How to rinse?
Take home!

• Rinsing is the best you can do!
• Always right!
• With nearby all you can drink
  (except hot fluids, lemon juice, brandy, vodka, ....)
• Type of burns
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CaO + H₂O $\rightarrow$ Ca²⁺ + 2 OH⁻

The amount of water limits the resulting hydroxyl ions

Rinsing without removal or foreign body increases the amount of hydroxyl ions
Subtarsal Lime
Remove foreign body and rinse to dilute and neutralize

Endothelium
Rinsing to cool!

Liquid metal
Take home!

• **FIRST AID MEASURES:**
  
  • Rinsing
  • Removal of foreign body
  • Rinsing = cooling
• Type of burns
• Mechanism of burns
• Dusts and Solid burns
• **Burns with fluids**
• Rinsing therapy
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Action af alkali

0,5 mol NaOH

0,5 mol NaOH-Lösung
Eye burn video

How long does it take to burn a cornea?

4 molar NaOH
Action of acids

0 min  HCl isoosmolar, pH2, 1 h incubation  60 min

24 h later cell death

coagulation
Take home!

**Action of burns differs:**

- Membrane destruction *(alcali)*
- Structural maintenance but loss of function in acids
• Type of burns
• Mechanism of burns
• Dusts and Solid burns
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• Do and do not!
cells incubated at 800 mOsmol/kg, rinsed with Tap-water
cells incubated at 800 mOsmol/kg, rinsed with Previn, Diphoterine
Take home

• Osmoshock causes additional trauma
• hyperosmolar solutions like Diphoterine® physically stabilise tissues best

• Diphoterine is not available in the US yet FDA process under consideration
• Type of burns
• Mechanism of burns
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Buffer or Water? Dilution versus efficient decontamination

- Are there limits of survival?
- If early rinsing wasn’t done is late rinsing efficient?
  - Case report: Merle et al. 4 mol NaOH burnt eye, Grad IV burn, resolved under conservative treatment rinsed with diphoterine® (Burns 2006)

- It is never too late! Why?
Even under extreme pH cell death is not an immediate fact!

NaOH pH 11.3 for 1 hour isoosmolar incubation
pH 9.1: survival of cells

0 min

60 min

24 h later
Survival below pH of 9

Proliferation in % of starting value

- 9.5
- 10.0
- 10.5
- 10.75
- 11.0
- 11.3
- Medium

Graph showing proliferation at different pH levels before and after exposure times.
pH over 5 essential for survival

![Graph showing proliferation over time and pH levels]
Which rinsing solution should we take?
changing of pH-value after adding rinsing solutions to 5ml 0.5 mol/l HCl-solution

- Ringers lactate
- Phosphate buffer
- Diphoterine
- Tap water
- NaCl 0.9%

Acids

Isotonic phosphate-buffer

Diphoterine ®

Ringers Lactate

Saline, Tap water
pH-change after addition of rinsing fluids to 5ml 0.5 mol/l NaOH-solution.

**Alkali**

- **Tap Water, Ringers Lactate, Saline**
- Isotonic phosphate buffer
- Sodium-Borate buffer
- Diphoterine ®

**Graph**

- x-axis: Zugabe [ml]
- y-axis: pH-Wert

Legend:
- rings lactate
- NaCl 0.9%
- phosphate buffer
- diphoterine
- Tap water
- borate buffer
Take home!

- Intraocular pH between 5.6 to 9.3 is important to achieve
- Only Diphoterine ® is acting on acids and bases
- Borate buffer (Cedderroths Eye wash solution ®) is doing well on alkali not on acids
eye burns with 2 mol NaOH filter paper 10mm for 20s, immediate rinsing with tap water for 15 min
mean of 5 measurements on rabbit eyes
Decide yourself:
Which solution do you want to be rinsed with in first aid?
Burns with 2 mol NaOH, stop with Diphoterine ® 1000 ml flow 66 ml/min (15 min)

No decontamination

Diphoterine ® decontamination
Take home!

- Diphoterine ® achieves physiological pH for acid and alkali
- Borate buffer does well for alkali
- Even with delay useful!
- As later rinsing starts as longer rinsing should be > 15 minutes!
• Type of burns
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Prospective double blind randomized therapy control study Burns with caustic soda (1 mol) rinsing therapy with saline or isotonic phosphate buffer. After 4 days 7 calcified and 7 non calcified corneas.
Patient burnt by Spitacid® treated by continued rinsing with isotonic phosphate buffer for 48 hours (8 weeks after burns)
Experimental rinsing with phosphate on a corneal erosion
Caustic soda burn rinsed once with physiological phosphate buffer
Clinical study
On 250 retrospective severe eye burns

Agent containing calcium:
  -> corneal calcification (p < 0.001)

Eye drops with phosphate:
  -> corneal calcification (p < 0.05)

Agent without calcium an first aid contains phosphate buffer:
  -> corneal calcification (p < 0.01)

Graefes Archives Ophthalm. Schrage et al 2004
Take home

• If you take phosphate buffer the cornea will calcify
• Better solutions Diphoterine, Previn are available (not in the US)
• Borate buffer (Cedderoths eye Wash) can be used for alkali
Films and downloads at www.acto.de