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A New Method of Treatment of the Hydrofluoric Acid Burns of the Extremities

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Summary. Based on animal experiments we describe a method of treating H.F. burns of the hand by intraarterial perfusion with calcium gluconate as close to the lesion as possible. We prefer this to intraarterial injection as advised by others because we have treated a series of 13 consecutive cases and know of many others in other hospitals with always yielding good results. We therefore advice the use of this therapy for H.F. burns as the best method available at present.

Key words: Intraarterial Calcium gluconate in HF burns.

It is one of the most difficult problems in the daily work of the trauma surgeon, to arrest the progressive changes of hydrofluoric acid burns, especially on the hands, often leading to severe deformities and even amputation, if inadequate therapy is administered. There is a direct connection between the extent of destruction on the limb and the concentration of the applied total amount of hydrofluoric acid, its contact-time with the skin, the therapyfree interval and finally the thickness of the cornified layer of the skin itself [3]. For this reason the immediate removal of the H.F. deposit from the skin by water irrigation remains an inflexible rule. Subsequently, attempts at precipitation with oxide or sulfate of magnesia or with caustic potash, iron cloride or quarternary ammonia compounds was proposed as a measure at the site of the accident, to prevent the formation of the typical grey-white coagulative necrosis. After the formation of skin necrosis local treatment usually fails (3) (Fig. 1). It is for this reason, that the majority of authors (6) nowadays advises early surgical intervention with total excision of the affected skin areas followed by skin grafting.

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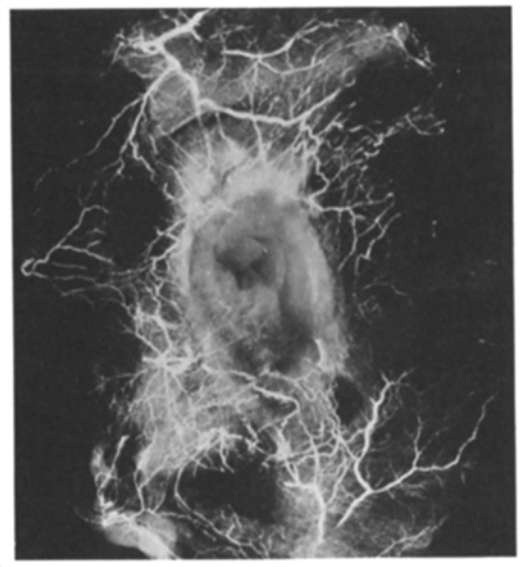


Fig. 1. H.F. burn 20% of a rabbit ear after excision and microangiography. 20% H.F. was used for only 1 minute and rinsed off after this time. A slough, destroying the vessels resulted, it can be seen in the middle of the picture

Attempts, to limit the fluoridation during the penetration through skin and subcutaneous tissue by local infiltration with calcium gluconate also in combination with Hyaloronidase and steroids were followed by little success. We could prove, that such subcutaneous infiltrations, even without a preceding H.F. burn are followed by extensive sloughs and gangrene (Fig. 2) (6).

Warburg has proved, that the corrosive nature of the H.F. burn is based on a toxic inhibitory effect of the fluoridation on the energy metabolism of the cell, which is reversible below the toxic concentration of 1 ml/mol per liter.

Carney showed that the fluoride concentration can be lowered below the toxic level by titration with calcium gluconate, while the calcium gluconate itself does not impair the viability of the cell in vitro.

Klauder treated successfully such cases with repeated intravenous calcium injections with concomitant oral and local application. The required dose of calcium in this method however proved to be dangerously high.

The Kyletest used for the diagnoses of diseases of the parathyroid uses an intravenous infusion of 15 mg/kg body weight calcium over 4 h. The following elevation or lowering of blood calcium level helps in the diagnoses of hypo- or hyperparathyroidism. In a bodyweight of 70 kg this dose corresponds to 1,050 mg calcium or 6 ampoules of calcium gluconate each 10 ml in a 20% solution.

It is natural to conclude that intraarterial perfusion of calcium gluconate into the supplying artery of a burned area will lead to a much higher local concentration in the area of the defect. After exclusion of toxic effects of intraarterially perfused calcium gluconate in animal experiments (1) on rab-

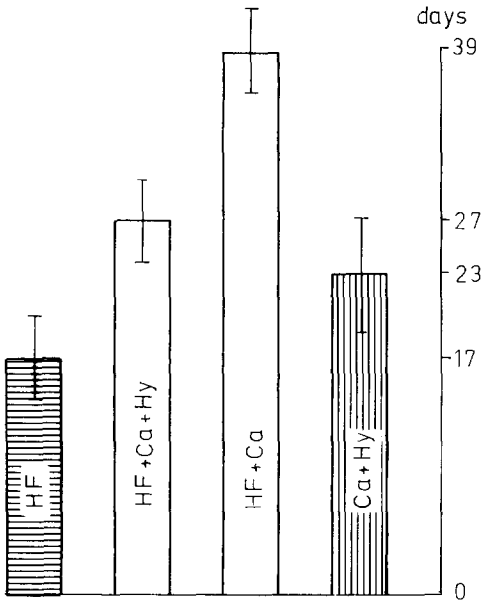


Fig. 2. Number of days until separation of slough in animal experiments. on rabbit ears of 1,5 cm diameter. First column 20% H.F. Second column H.F. plus calcium gluconate plus Hyaluronidase. Third column H.F. plus calcium gluconate. Fourth column calcium gluconate plus Hyaluronidase

Fig. 3. Perfusion with calcium gluconate over the radial artery using an infusomat

bits we found the following scheme of therapy for the treatment of hydrofluoric acid burns on the hand.

Method of Treatment

1) The treatment should begin as early as possible.

2) Before starting the perfusion an arteriogram has to be done using regional anesthesia. Depending on the location of the lesions the route of perfusion is chosen over the radial, ulnar or brachial artery (Fig. 3).

3) The perfusion over the lower arm arteries is started as close to the defect as possible with 10 ml calcium gluconate in 20% solution using a perfusor which was filled up to 50 ml with normal saline. In burns which effect the area supplied by both arteries the infusion into the brachial artery with 20 ml calcium gluconate 20% sol. is carried out over 4 h (Fig. 4). We prefer this technique rather than the method of Bartels who uses intermittent intraarterial injections.

4) The perfusion is repeated in 12 h intervals until the patient is painfree and the inflammatory symptoms have completely subsided and a clear demarcation of the sloughs is recogniceable.

5) During the total insertion time of the arterial catheter a liquid infusion with 200 U. liquid/kg bodyweight is performed.

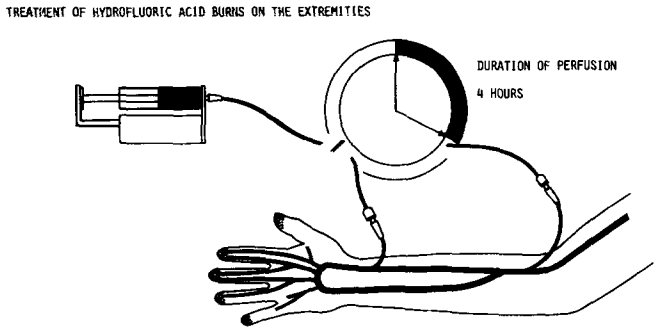


Fig. 4. The intraarterial perfusion scheme used in our patients with 10 ml calcium gluconate 20% + 40 ml normal saline 0,9% over the radial or ulnar artery or with 20 ml calcium gluconate 20% + 30 ml normal saline 0,9% over the brachial artery

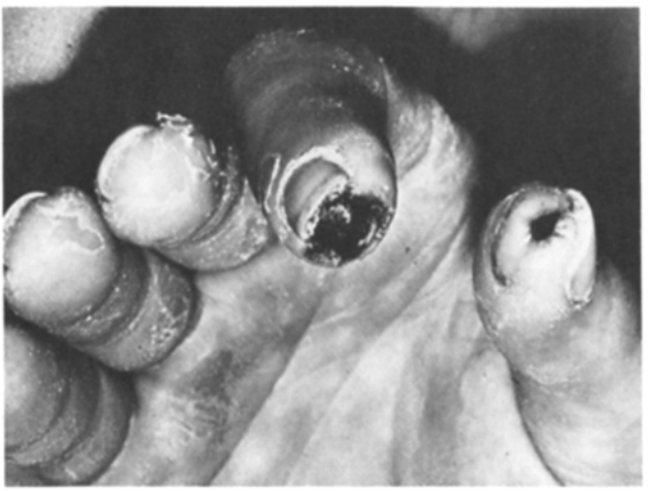


Fig. 5. H.F. fingertip burns in a painter. 2 courses of perfusion over the radial artery, first one 1 hour, second one 12 hours after the burn

6) Until the definite ending of the perfusion a local bath of calcium ions is obtained by application of calcium gluconate soaked compresses to the burned areas.

The serum calcium level even in perfusion of 20 ml 20% calcium gluconate increases only slightly over the upper normal values.

The use of the arterial way by percutaneous arteripuncture is possible. Since however the resulting traumatization of the vessel with haematomata and uncontrollable resulting tissue trauma present definite risks, we prefer the opening of the artery through a skin incision and the insertion of a catheter under direct view. The excision of the sloughs should only take place after the first perfusion since under calcium perfusion we regularly observe a recovery of tissue that at first seemed to be necrotic. Remaining defects are either closed by skin graft or left to spontaneous epithelialization.

Immediately after the start of the perfusion the patients notice a decrease or complete disappearance of pain and sometimes a feeling of warmth in the perfused extremity.

Table 1. Casuistic

No.	Age	Sex	Protession	HF%	Cocation	No. of per-fusion	Skin graft	Healing time in weeks
1	36	m	painter	20	rt. hand	2	–	2
2	40	m	chemist	80	rt. ringfinger	3	+	4
3	27	m	glassworker	20	rt. indexfinger	1	+	3
4	24	m	glassworker	20	all fingertips	1	–	2
5	18	f	forceworker	20	fore arm	2	+	4
6	21	m	painter	20	all fingertips	1	–	2
7	32	m	painter	20	all fingertips	1	–	2
8	47	m	painter	20	all fingertips	1	–	2
9	19	f	glassworker	20	rt. indexfinger	1	–	2
10	23	m	glassworker	20	rt. thumb	1	–	2
11	35	m	painter	20	dorsum left hand	3	–	$2^1/_2$
12	35	m	glassworker	20	fingertips 2–5	2	–	1
13	18	m	glassworker	20	rt. indexfinger	1	–	2

Case Reports (Table 1)

Following is described the clinical course and end results using the therapy described above in typical clinical cases.

Case 1

Is a 36 years old painter (Fig. 5), who worked with a dye remover, containing 20% H.F. and injured his right hand. He was treated with two courses of perfusion (Fig. 6 and 7).

Case 2

The next patient (Fig. 8) is a 40 years old chemist, who worked with 80% H.F. and burned his right indexfinger. He came 12 hours after the accident for admission. He already presented circumscribed sloughs. The arteriogram showed the blood supply to come over the ulnar artery alone. Two perfusions were performed over the ulnar artery and one over the brachial artery. After the progression of necrosis was stopped, the slough was excised and replaced by a full thickness skingraft (Fig. 9) from the wrist. The excised slough (Fig. 10) showed deposits of calcium (Fluoride?) in the subcutaneous layer.

Case 3

Another typical case showes the greyish discoloration on the radial side of the fingertip of the indexfinger (Fig. 11). After one course of perfusion and excision of the slough (Fig. 12) the wound became clean (Fig. 13) for grafting which was performed uneventfully.

Case 4

One last picture (Fig. 14) showes the typical greyish white discoloration on the fingertips of a glass factory worker, who used 20% H.F. for cleaning. This healed uneventfully after one course of perfusion. Without perfusion the tips of all fingers would almost certainly have been lost or mutilated, which was our experience with former cases using local injection therapy.

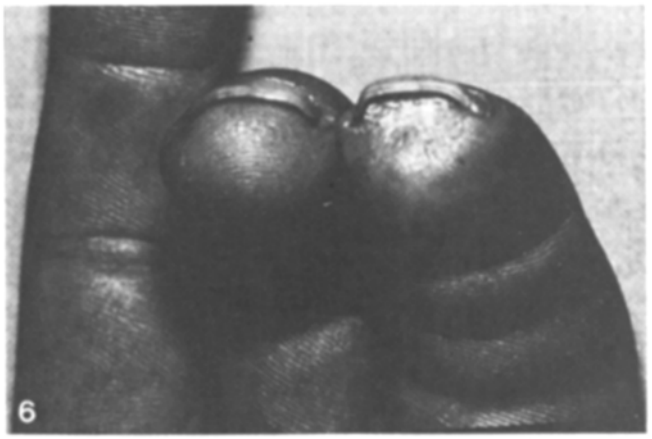
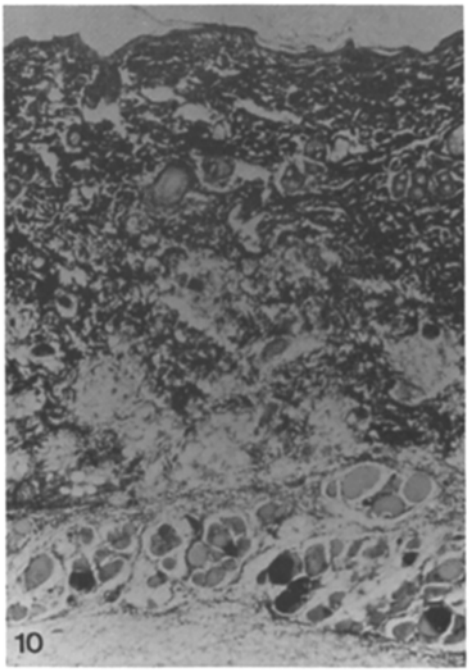


Fig. 6 and 7. Appearance after two courses of perfusion of the radial artery. 3 weeks after the burn, spontaneous epithelialization, firm, stable, nonpainful scar

Fig. 8. Index finger of a forty year old patient after burn with 80% H.F. 12 h after the burn



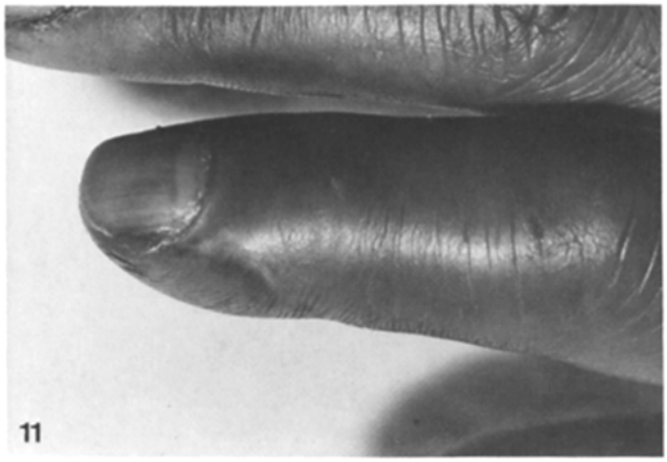


Fig. 9. The same finger as in Fig. 8 3 weeks after two courses of perfusion over the ulnar artery and one over the brachial artery in 12 h intervals. Excision and full thickness skin graft from the wrist after 4 days

Fig. 10. Excised slough of the same patient showing calcium (fluoride?) deposits in the subcutaneous layer. Excision 4 days after the burn after 3 courses of perfusion

Fig. 11. H.F. burn on an index finger tip in a glass worker 1 h after the injury

Fig. 12. Same indexfinger as in Fig. 11 after one course of perfusion immediately after admission and excision 12 h later

Fig. 13. The same finger as in Fig. 11 and 12 six days later, ready for grafting

Fig. 14. Typical appearance of a hand, immediately after burning with H.F.

Discussion

H.F. burns occur mainly in glass factory workers cleaning glass and painters, mostly on the finger tips using paint remover. With 1–3 perfusions and removal of the slough, healing was usually complete after 1–4 weeks, skin grafts were seldom necessary. We prefer the slow perfusion with calcium gluconate with an infusomat over the injection, which Bartels uses, because we believe, that this method with its short and high concentrations can more readely change the arterial wall than a slow perfusion, plus the fact that the local effect is only short lived using this form of application. We observed no side effects of our therapy.

References

1. Achinger R, Koehnlein HE (1979) Eine neue Behandlungsmethode von Flußsäureverätzungen an den Extremitäten. Chir Forum Exp Klin Forsch 229
2. Bartels L (persönliche Mitteilung) Eine neue Behandlungsmethode bei der Flußsäureverätzung. Koloquium der TU München, 26.1.1982; sowie Poster Ausstellung, Chirurgenkongreß 1981, München
3. Carney SA (1974) Rationale of the treatment of hydrofluoric acid burns. Br J Intern Med 31:317
4. Klauder JV, Shelanski L (1955) Industrial uses of compounds of fluorine and oxalic acid. Arch Ind Health 12:412
5. Jakobitz K, Buchartowski H, Koehnlein HE (1977) Eine neue Behandlungsmethode von Flußsäureverätzungen an der Hand. Mikrovaskuläre Chirurgie, Plastische Chirurgie. VLE, Erlangen, S 128
6. Koehnlein HE, Merkle P (1973) Hydrogen fluoride burns: Experiments and treatment. Surg Forum 24:50
7. Warburg O, Christian W (1941) Isolierung und Kristallisation des Gärungsferments Enolase. Biochem Z 310:384

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