CAUSTIC SODA BURNS: THEIR PREVENTION AND TREATMENT

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Caustic soda, widely employed before the war in various manufacturing processes, is finding increased use in many wartime industries. There is a demand for information on the best way to prevent or deal with the injuries that may result to the workers, and this article is an attempt to satisfy that demand. It is based on thirteen years' experience in a works where many tons of caustic soda are manufactured every day. It is also hoped that criticisms and fresh ideas may be forthcoming for the improvement of the methods here described.

These methods have been evolved gradually. Before they were adopted a large number of men were always away from work with caustic soda burns of the skin, which took many weeks or months to heal. These burns had the appearance of black leather inlays in the skin. There are lifelike wax models of such burns in the Home Office Museum, Horseferry Road, Westminster.

Previously, caustic soda burns were treated by the application of bicarbonate of soda—with the intention that it should react with the caustic soda to form carbonate of soda—followed by washing with plain water. The results of this old-established treatment were unsatisfactory. For several days the burns appeared to become deeper each day. The sloughs were allowed to separate spontaneously, and the resulting exposed area of granulations showed no sign of healing for a considerable period and afterwards healed very slowly. On one occasion, to obtain rapid healing, a narrow burn on the forearm was excised with a margin of healthy skin on each side and the wound was sutured. Microscopical sections of the excised burn were prepared. The burn appeared to be a structureless coagulum, the adjacent tissue being crowded with leucocytes. The phenomena observed in inadequately treated caustic soda burns suggested that the coagulum of necrosed tissue held some uncombined caustic soda, which diffused into the deeper tissues for a few days, increasing the depth of the destroyed tissue and perhaps impairing the vitality of adjacent tissue that was not actually necrosed.

Caustic soda burns of the eye formerly were washed out with boric acid solution for two to five minutes at the time they happened. A prolonged period of inflammatory reaction followed, with the formation of granulation tissue over the sclerotic and the inner surfaces of the eyelids. This resulted in symblepharon. Some of the old hands have tough bands of adhesion between the eyelids and the eyeball, limiting the movement of the eye and causing considerable inconvenience. Burns of the cornea were still more serious.

Prevention

The engineer conducting a process involving the use of caustic soda should make it, when possible, a closed process, so that workers cannot come in contact with the substance. If this is impossible, pools of liquid caustic soda on the ground or leaking pipes, tanks, etc., should not be allowed. If, in spite of all precautions by the works management, the worker comes in contact with the caustic soda, the part of the body affected should at once be drenched with a current of neutralizing solution, not by immersion or compresses.

At first sight a weak solution of an acid such as citric acid, acetic acid, or hydrochloric acid appears to be a satisfactory neutralizing medium; but weak acids, if used as irrigants, might react with the tissues as well as with the caustic soda. Ammonium chloride, on the other hand, is a neutral salt that will not react with the tissues but only with the caustic soda with which it makes contact, instantly neutralizing it, with the formation of sodium chloride and the release of ammonia, which is washed away by the bulk of the unchanged irrigating solution. Our adoption of this treatment during the last 12 years has almost brought about the disappearance of caustic soda burns of the skin.

Caustic Soda Burns of the Skin

Throughout the caustic soda plant are placed large vessels (aspirators), each containing 5 gallons of 5% solution of ammonium chloride, in cupboards with open fronts, painted red to attract attention. These vessels are placed also at other points in the works where caustic soda is used. The necks of the vessels by which the solution is introduced are closed by a large rubber stopper. The rubber stopper is penetrated by a thistle-tube, to admit air for the easy withdrawal of the solution. The bulb of the thistle-tube is lightly packed with cotton-wool to prevent caustic soda dust from falling into the solution and destroying its usefulness. There is a rubber bung at the base of the aspirator, penetrated by a large glass tube to which a rubber tube about 6 feet long is attached. A spring clip controls the rubber tube and serves to hang up the latter on a hook when not in use. The clip can be instantly slipped off the tube when necessary, thus releasing a free flow of the solution. If a man gets caustic soda, solid or liquid, on his skin or clothing he runs to the nearest aspirator, unhooks the tube, presses the clip, and releases a deluge of the solution on the part affected. This stops the action of the caustic soda instantly, and in the great majority of cases prevents a burn. The number of caustic soda burns has been very greatly reduced by this method. It has gained the confidence of the men, who appreciate what it does for them. As an indication of this, as much as 12 to 20 gallons may be used on the plant in 24 hours without any caustic burn taking place. It is an advantage that the ammonium chloride solution is perfectly harmless to the tissues and will not injure the eyes (it has a very corrosive action on most metals).

If there has been such delay in the application of the ammonium chloride that destruction of the epidermis has taken place, and there is in fact a burn, the part should be drenched with a current of ammonium chloride solution for 10 to 15 minutes and then with plain water or normal saline for one hour continuously. This treatment will minimize the severity of a burn and prevent it becoming as deep as it otherwise would. It is then treated as a heat burn. Everyone has his own ideas about the treatment of burns; but we have treated them by washing the area with soap and water, removing dead tissue by a gauze swab soaked in alcohol, and then washing with ether. A fourfold pad of plain white sterilized lint soaked in a 2% solution of tannic acid is then applied and secured by a bandage. This pad is left in place, without attempting to separate it, until it is able to fall away by its own weight when the bandage is removed. This takes place in three weeks, more or less.

In the uncommon cases in which a burn has occurred through delay in irrigating with ammonium chloride solution, this has happened because access to the ammonium chloride solution has not been obtained soon enough (30 to 40 seconds), and occasionally a man has been unaware of contact with caustic soda until burning has taken place. In rare cases a man of dull wits has not troubled to go to the solution and has had to be treated for a deep burn of the old type. Deep caustic soda burns of the skin when they occur have lately been treated by obtaining a firm crust by the application of the tannic acid compress and, after this has formed, applying blue paint to the burn and dressing it with gauze soaked in blue paint. Blue paint was introduced by Bonney, and consists of 1 part brilliant green, 1 part crystal violet, 99 parts rectified spirit, and 99 parts water. This lessens the risk of infection in a deep burn.

Caustic Soda Burns of the Eye

The wearing of properly designed and well-fitting goggles should be compulsory, and this will usually prevent caustic soda from reaching the eye; but it seems impossible to ensure that goggles shall be properly worn on every occasion when there is danger. For the treatment of these cases, eyewash-bottles should be available every few yards in any plant where there is possibility that caustic soda in solid or liquid form may reach the eye, and should be placed in little cupboards fixed at a convenient height, with open fronts and painted red to be conspicuous. The bottles, which contain 5% ammonium chloride solution, should be 8-oz. wide-necked ones, the neck closed with a rubber stopper with two holes—one for the air-inlet tube, which is carried to the bottom of the bottle

and need only project from the stopper half an inch, and the other for the irrigation tube, which is bent at an obtuse angle outside and penetrates only for about a quarter of an inch beyond the stopper inside the bottle. The eyewash-bottle is used by turning it upside down and flushing the eye by gravity flow. Any attempt to modify the bottle so that it may be used like a wash-bottle in a chemical laboratory, by mouth-blowing, must be forbidden. It may be injurious.

If a man gets caustic soda in the eye, first aid must be given without delay: for this reason every man should be provided with a whistle to summon aid if necessary. Delay may lose an eye. The first-aider must take a wash-bottle from the nearest cupboard and, parting the eyelids with the finger, flush the eye with the contents of the bottle. The patient should then be taken at once to the plant surgery, which should be close to the caustic-soda plant and preferably with a laboratory adjacent, as this will ensure that a man trained in ambulance work is always available. About four specially trained men must be available on every shift, to give treatment in the plant surgery. Two of them must have instructions to leave their job and attend to the injured man immediately. He should be placed flat on his back on a couch, the foot of which is raised slightly. The eye must be irrigated continuously for one hour by the clock, with which the plant surgery must be provided. Irrigation must be performed for the first five minutes with 5% ammonium chloride solution, and for the rest of the hour with boric-saline solution, prepared as described below. During the irrigation care must be taken to pull the lower eyelid down gently so that the irrigation may reach the inferior fornix; and the injured man should be told to roll his eye from side to side so that the conjunctiva of the inner and outer corners of the eye may be reached. The upper eyelid should be gently elevated by the fingers of the first-aider, and the patient told to turn the eyeball downwards periodically so that the conjunctiva of the upper fornix may be reached.

This irrigation of one hour's duration is of supreme importance, and must be started at once. To send a case to hospital without such preliminary irrigation confronts the hospital with damage which is irreparable and which could have been prevented at the time of the accident by the measure described. In practice this treatment has reduced the time of recovery of caustic soda burns of the eye from weeks to days.

If the case is to be attended to by the works doctor he will see the patient every day and will instruct the ambulance-room attendant to irrigate the eye with warm boric-saline for 5 or 10 minutes three or four times a day, afterwards passing a blunt-pointed glass rod loaded with soft boric ointment first of all between the upper eyelid and the eyeball and then between the lower lid and the eyeball. If this is done no case of symblepharon will ever occur. The doctor will use atropine drops, argyrol solution (20%), or hot fomentations where he considers these measures are indicated. We find it advisable to adopt the first two measures in all but the mildest cases. It will be necessary for one man to be responsible for the ammonium chloride irrigators and eyewash-bottles. He must inspect them every day and fill all those that have been used. The works doctor will occasionally examine these vessels to ascertain that this is being done. Pools of caustic soda liquid on the ground and leaking joints will of course not be tolerated by the engineer-in-charge. If they are, the works doctor should have something to say about it.

With us, the tannic acid solution is made up in winchesters of 2.5-litre capacity; the date is written on the label, and any that has not been used is replaced by fresh solution at the end of three months. It is a great advantage, too, that it should be ready for instant use: tablets dissolve slowly. The cost of renewal is negligible. The quantities used are:

Tannic acid	50.0 grammes
Mercuric chloride	1.25 "
Water	2.5 litres

The boric solution is kept in winchesters at double strength in order that it may be diluted with an equal quantity of warm water when it is to be used. One ounce of common salt and half an ounce of boric acid are dissolved in a winchester of distilled water. We have found it convenient to have this solution ready made up in winchesters for immediate use.

Saline by itself grows a mould. The addition of the boric acid prevents this happening.

Summary

Cases of contact of caustic soda with the skin are dealt with by immediate irrigation with 5% solution of ammonium chloride; by which means a burn is prevented if the irrigation is done within 30 to 40 seconds of contact.

If delay has resulted in a burn, its severity is very greatly lessened by irrigation with ammonium chloride solution.

Irrigation of the eye with 5% ammonium chloride solution, followed by irrigation with warm boric-saline lotion for one hour, reduces the severity of the eye injury to a very marked degree, so that recovery takes place in one-fifth to one-seventh the time taken with older methods.

Treatment by ammonium chloride solution must always be carried out by immersion, never by immersion in a static solution or by compresses.

Medical Memoranda

Notes on Treatment of Respirator Dermatitis

Since the publication of Petro's article on respirator dermatitis (*British Medical Journal*, 1942, 1, 631) 25 cases have been admitted to a certain military hospital. The first 13 cases were treated on lines similar to those laid down in that article—viz., using calamine lotion and liniment, Burow's solution, and various creams such as 1% ichthylol in zinc cream. In no case could the progress be described as satisfactory, and in order to reduce the number of days of hospital treatment other methods were adopted.

The most successful method was what I shall call the saline soak technique. In this series 12 cases were treated; every case was a severe affection, associated with vesiculation, weeping, and crusting. With few exceptions they responded dramatically to the use of normal saline soaks, similar to those for the treatment of burns. Very rapidly the crusts are removed, the weeping ceases, and epithelization occurs without delay.

DETAILS OF TECHNIQUE

A white lint mask covering all affected areas is soaked in normal saline and applied to the face areas and covered by jaconet. It is essential to keep the lint moist throughout; this can be done by pouring on normal saline at frequent intervals. If the lint should become dry it is vital to soak thoroughly before removing. It is advisable to remove the lint from the face four-hourly, and to renew, so as to remove crusts. In some cases the face returned to its normal condition in 24 hours, and in all cases there was a rapid improvement. When the weeping areas have epithelized either zinc cream or 1% ichthylol paste should be applied.

A typical example is illustrated in Pte. A., aged 18, who was admitted to hospital on Dec. 4, 1942, two weeks after he was called up, having worn his respirator for 10 minutes the week previously, and again for 30 minutes three days before admission. The rash appeared 24 hours before he was admitted. He was suffering from a typical respirator dermatitis, affecting the forehead, cheeks, chin, and tip of the nose, all areas being covered with golden crusts. This case was treated with normal saline soaks in the manner described; after 24 hours there was a marked improvement, all crusts having disappeared, leaving a clean raw area. Treatment was stopped after 48 hours and the condition was cured in three days. Not all cases clear so dramatically, and most require a little zinc cream following the saline.

COMMENT

All these cases were moderately severe, affecting the contact areas of the face—viz., frontal, malar, masseteric, mental, and submental areas, with occasional lesions on the nose. Some cases proved more resistant to treatment than that of Pte. A., but comparison with other methods shows a marked advance. Another point of importance in the treatment is the advisability of not performing any patch test with rubber from the face-piece of the patient's own respirator until the skin is settling down or even healed, as a number of cases were aggravated by so doing; and even in one case after the skin was thoroughly healed the patch test caused relapse.

The saline technique seems to be the method of choice, and certainly takes precedence over those mentioned in the article quoted.

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