assistance. We are grateful to members of the medical and nursing staff at University College Hospital, Ibadan, who volunteered their assistance during the trial. We would also like to thank the Western Nigerian Broadcasting Service for help in publicizing the trial.

The vaccines were kindly supplied by the Wellcome Research Laboratories and by Professor A. A. Smorodintzev, Pasteur Institute, Leningrad.

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Medical Memoranda

Survival After High-tension Electrical Burns Complicated by Acute Tubular Necrosis

Brit. med. J., 1966, **1**, 781–782

Recovery from acute tubular necrosis resulting from high-tension electrocution is unusual (Alwall, 1958). This paper therefore presents the characteristic features shown by two victims of such accidents seen by us in the last 18 months. The management of the second patient was facilitated by the local application of a cream containing organic acids (Aserbine), which obviated the need for surgical desloughing.

CASE 1

A 44-year-old man accidentally touched a high-tension cable (33,000 volts) while descending an iron ladder. On admission shortly afterwards he was conscious but unable to move either arm. The coins in his pocket had been partially melted and he had sustained full-thickness burns on both arms and a partial-thickness burn on the right leg—in all about 10% of the body surface area. Within 48 hours both arms became very swollen and hard, but the radial pulses remained good. The left arm was totally anaesthetic and the right arm was anaesthetic below the level of the insertion of the deltoid. Both arms remained completely paralysed apart from slight movements of the shoulders.

His systolic blood-pressure never fell below 100 mm. Hg, yet during the first 48 hours he passed only 400 ml. of brown urine, which showed a strong absorption band characteristic of methaemoglobin. By the second day his plasma urea was 208 mg./100 ml., potassium 7.9 mEq/l., and bicarbonate 10 mEq/l. Eight haemo-

dialyses were required to control the hyperkalaemia and uraemia during his 30 days of oliguria.

The dressings were removed for the first time on the eleventh day because of a copious discharge of pus containing penicillin-resistant staphylococci from a deep wound in the left axilla. Though the infection responded to fusidic acid, a haemorrhage of about 250 ml. from the left axillary vein necessitated amputation of the arm on the eighteenth day. The left latissimus dorsi (Fig. 1) and all the muscle groups in the arm were stippled by pale necrotic muscle bundles despite the complete patency of all the arteries.

After the operation his general condition immediately began to improve and 13 days later his 24-hour urine volume exceeded 500 ml. for the first time. By the fifth week the amputation wound and the burn on the leg had healed, the paralysis and anaesthesia of the right arm had not improved, and areas of necrosis had become demarcated over the elbow and ulnar side of the forearm.

When these wounds were desloughed surgically on the forty-third day it was apparent that the distal one-third of the biceps and 3 in. (7.6 cm.) of the median and ulnar nerves had been destroyed in the antecubital fossa. The radial nerve was swollen, soft, and haemorrhagic, but as it was in continuity it was left *in situ*. Two weeks later the forearm had to be desloughed again because of necrosis of tissue which had initially appeared viable. On the sixty-seventh day the skin defects in front of the elbow and on the forearm were grafted and by the fifteenth week the arm had healed completely.

By October 1965 normal sensation had returned in the distribution of the radial nerve and the patient had some active, albeit weak, extension at the elbow, wrist, and metacarpophalangeal joints. His general health was excellent and his blood urea was 35 mg./100 ml.

CASE 2

A 39-year-old schizophrenic man attempted suicide by grasping a high-tension wire (33,000 volts). He sustained small full-thickness burns on the palm of the left hand, the right buttock, and sole of the left foot, and extensive, partial, and full-thickness burns on the right side of the body, totalling about 20% of the body surface. Two pints (1.1 litre) of blood and 5 pints (2.8 litres) of plasma were required in the first three days. He became oliguric almost immediately, and his plasma urea had risen to 141 mg./100 ml. and plasma potassium to 7.1 mEq/l. by the second day.

The whole of the right arm became indurated and swollen to a circumference of 35.5 cm. at the mid-humeral level—that is, about 10 cm. more than the unaffected arm. The dorsum of the right hand was anaesthetic for two days, but all movements were present at about half normal strength and have remained so.

The burns were initially treated by exposure, but from the eighth day Aserbine cream was applied to the burns daily. By the thirtieth day the sloughs had separated to reveal either healed areas or healthy granulations (Fig. 2), and to expose the pectoralis major tendon in the right axilla. A little pus drained from this wound but otherwise there were no signs of infection. The patient's temperature rose to 100° F. (37.8° C.) each day during the first and third weeks of this treatment but the fever seemed to respond to antibiotics. Despite the oliguria no other toxic effects due to Aserbine were detected. No desloughing operation was required and the wounds

FIG. 1.—Section of latissimus dorsi from Case 1 stained with haematoxylin and eosin to show necrotic muscle as dark patches.

were successfully grafted on the fifty-third day, 14 days earlier than in Case 1.

FIG. 2.—Case 2 after removal of sloughs with Aserbine. Granulations are clean and ready for grafting.

This patient also required eight haemodialyses during the 40 days of oliguria. Diuresis started 10 days after the wounds first appeared clean. By the tenth week his plasma urea had fallen to 32 mg./100 ml., and his creatinine clearance was 35 ml./min.

COMMENT

Both patients demonstrated features of the two types of burn caused by high-tension electrocution.

True Electrical Burns.—These are produced by the heat generated where the current enters and leaves the body through the high electrical resistance of dry skin. The current then passes through the core of the body, which is a good conductor because of its water and electrolyte content. Muscle, nerve, and blood-vessels are damaged, and secondary haemorrhage or gangrene, due to vascular thrombosis, commonly occur (Jaffe, 1928; Critchley, 1935; Dale, 1954; McLaughlin and Coe, 1954; Ingelrans, Delmote, and Poupard, 1957; Muir, 1958). This damage may be caused by heat generated by the electrical resistance of the tissue or by a direct effect of the current on metabolic processes such as the maintenance of the electrical potential of the cell membranes (Dale, 1954).

Flash Burns.—These are thermal burns of skin produced by arcing between the high-tension source and the victim.

The extensive muscle necrosis probably accounts for the clinical features, which bear a striking resemblance to the crush syndrome.

Oedema.—This reaction to dead muscle increased the volume of the arm of our second patient by about 2 litres and produced a similar amount of swelling in both arms of the first patient. Extravasation of this order must be taken into account in calculating the fluid required for resuscitation.

Hyperkalaemia.—This is predominantly due to release of intracellular potassium from damaged muscle but is aggravated by acidosis and oliguria. Since it may rapidly reach dangerous

proportions, the plasma potassium concentration should be measured at least once daily.

Anuria.—This results from the deposition of myoglobin casts in the renal tubules and the development of acute tubular necrosis. Slow absorption of dead red cells and muscle may cause continued formation of casts and delay recovery from the tubular necrosis. In both our patients diuresis occurred about two weeks after removal of necrotic tissue—in Case 1 after amputation of the arm and in Case 2 after all the sloughs had separated. Stephens and Stewart (1965) made a similar observation in a patient with thermal burns, so it might seem logical to advocate the early removal of dead tissue.

This does not appear to be practical advice in electrical burns, since the depth of the burn and the eventual extent of tissue necrosis are difficult to determine. Early excision is therefore particularly liable to be incomplete, and in Case 1 even a late desloughing had to be repeated before healthy tissue was exposed. Moreover, the administration of an anaesthetic and the stress of surgery are hazardous in uraemic patients.

Aserbine cream contains malic acid 250 mg., benzoic acid 25 mg., salicylic acid 5 mg., and malic acid ester of propylene glycol 160 mg./100 g. A controlled study of the effect of this preparation on 30 burned patients showed that it is bacteriostatic and aids the separation of slough without apparently affecting living tissue (Crawford and Rozner, 1965). The depth of the burn is assessed in retrospect, since partial-thickness loss heals spontaneously and areas of full-thickness loss granulate. The burns can be grafted earlier, so scarring and contractures are reduced.

We detected no toxic effects attributable to the use of Aserbine on an oliguric patient. The mild pyrexia, which is common during the use of cream, is at least partly due to the absorption of protein products of slough breakdown from the wound (Crawford and Rozner, 1965).

Finally, the eventual recovery of function of the radial nerve, which was seen to be partially necrotic in Case 1, shows that the prognosis of a nerve injury produced by electrical current is not hopeless. A nerve should not be sacrificed if it is in continuity.

We are most grateful to the nursing staff on the renal unit and on the plastic surgery ward for their skilled care of these patients and to the many medical registrars who carried out the haemodialyses.

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