Discussion

Hydrofluoric acid is commonly used in industry as a cleaning agent for metals and glass.[1] Burns resulting from contact with it may present early or late to the A&E department. Early presentation, with severe pain, occurs with concentrations of greater than 20%.[2] Burns resulting from more dilute forms of the acid may present with delayed onset of pain, erythema, and crust formation at the site of the burn. One of the characteristic features of hydrofluoric acid burns is intense and often delayed pain. This may occur despite standard first aid treatment. The pathophysiology is said to be the permeability of the fluoride ion, which enables it to rapidly penetrate skin, subcutaneous tissues, and bone. Rapid binding of calcium by the fluoride ion forms insoluble salts, and the ensuing drop in local tissue calcium interferes with cellular function and causes cell death. Cell death in turn releases large amounts of potassium, which irritates nerve endings, causing severe pain.

Methods of treating these burns are aimed at local pain control and prevention of progressive tissue damage. The most effective of these has repeatedly been shown to be the local infiltration of calcium gluconate or application of topical calcium carbonate to bind the fluoride ion, forming an insoluble salt.[1 3] This removal of the free fluoride ion prevents progressive tissue necrosis and achieves simultaneous pain control. More recently, the identification of severe hypocalcaemia associated with fluoride loading has raised concerns over the life threatening, rather than limb threatening, nature of this injury.[4 5]

Topical and local infiltration using gel or local injection are, however, not without problems. Gel may be ineffective, particularly in delayed presentations. Local infiltration is often found to be to exceedingly painful, and has the added disadvantage of potential compromise to the local circulation, possibly requiring concomitant fasciotomies when treating digital burns.[2] The use of local anaesthetic infiltration is contraindicated, as the cessation of pain is used as an indicator of effective treatment.[1] Intra-arterial infusion has been advocated, but is technically more demanding and potentially more hazardous.

Regional intravenous calcium injection using a Bier's block technique satisfies all the aims of effective treatment of hydrofluoric acid burns. The 15 ml of 10% calcium gluconate, if released suddenly, can cause flushing, headache, and arrhythmia, so we recommend the use of a double cuff tourniquet and cardiac monitoring during the procedure. Despite these potential problems we feel that this amount of calcium is safe, given that there is rapid binding to fluoride. Furthermore, the risks must be balanced against the hazards of continued tissue destruction and the need for adequate pain relief. Both these patients received rapid and complete analgesia, tissue necrosis was halted, and possible systemic effects from either the burn or its treatment were avoided. This procedure is technically much simpler and seemingly safer than intra-arterial infusion. It is easy to perform in an A&E department when the patient first presents. Doctors working in A&E departments should be aware of this procedure, which can be used effectively to treat hydrofluoric acid burns to both upper and lower limbs.

1 Chick LR, Borah G. Calcium carbonate gel therapy for hydrofluoric acid burns of the hand. Plastic Reconstr Surg 1990;86:935–9.
2 Anderson WJ, Anderson JR. Hydrofluoric acid burns of the hand: mechanism of injury and treatment. J Hand Surg 1988;13A:52–7.
3 Blunt CP. Treatment of hydrofluoric acid burns with injection with calcium gluconate. Indust Med Surg 1964;33: 869–71.
4 Kohnlein HE, Achinger R. A new method of treatment of hydrofluoric acid burns of the extremities. Chir Maxillofac Plast 1982;6:297–305.
5 Sheridan RL, Ryan CM, Quinby WC, Blair J, Tomkins RG, Burke JF. Emergency management of major hydrofluoric acid burns. Burns 1995;21:62–4.

Stun gun injury

Peter Burdett-Smith

Accident and Emergency, The Royal Liverpool University Hospitals, Liverpool, UK
P Burdett-Smith

Correspondence to:
Mr P Burdett-Smith, Consultant in A&E Medicine, The Royal Liverpool University Hospitals, Prescot Street, Liverpool L7 8XP.

Accepted for publication 13 June 1997

Abstract

A case is presented of injury by a "stun gun." The different types of electric shock devices produced commercially are summarised and the potential injuries discussed.

(*J Accid Emerg Med* 1997;14:402–404)

Keywords: stun gun; electrical burn

Case report

A 58 year old man attended the accident and emergency (A&E) department after being attacked with what he described as a "cattle prod" during a robbery. He described sparks being emitted from the device, which was deliberately applied to the dorsum of his right hand as he tried to defend himself. Examination revealed a partial thickness electrical burn to the hand, with extensive soft tissue swelling. The wound was dressed and he was reviewed in the clinic.

Figure 1, taken 10 days after the assault, shows the haematoma secondary to the deep soft tissue injury. Just visible are the contact points of the electrodes on the skin. The haematoma was aspirated and the injury resolved in four weeks.

Discussion

There are three main types of device designed to (deliberately) impart an electric shock: stun guns, shock batons, and cattle prods.[1] They share the same basic design but differ in energy output and potential for injury.

STUN GUN

Developed in America in 1979, stun guns are hand held, battery operated devices, with a variety of names such as "Cosmic Defender" and "Lightning Strike." Similar in design to cattle prods, with two electrodes approximately 5 cm apart, they are designed to be pressed against the victim's skin and an electric shock is administered when the switch is pressed. A variety of warning devices are incorporated into some models, including two further electrodes placed approximately 2 cm apart and facing together, which produce visible arcing, and lights or audible warnings to would be assailants. In some models, the electrodes are sharp and designed to penetrate the skin.

A development of this principle is the "Taser" (Thomas A Swift's electric rifle), used in the USA by police officers.[2] This resembles a large torch, but beneath the light source are housed cassettes containing two darts with barbed hooks at one end and a spool of fine wire connecting them to the device proper. When the trigger is pressed, the darts are fired up to a distance of 15 feet, and are designed to embed in clothing or the skin. Pressing the trigger activates the current, causing tetany of the muscles, usually causing the victim to fall. The current is effective through up to 5 cm of clothing. After the victim has been restrained, the wires have to be cut, and the patient taken to hospital for the darts to be removed under local anaesthesia. In North America they are considered useful weapons for dealing with people deranged by the effects of drugs, especially PCP (phencyclidine), as the alternative method of subduing is the .38 special with a 50% mortality! It is also possible to remove the cassettes from the Taser and insert extendible 12 inch electrodes, allowing the instrument to be used as a stun gun.

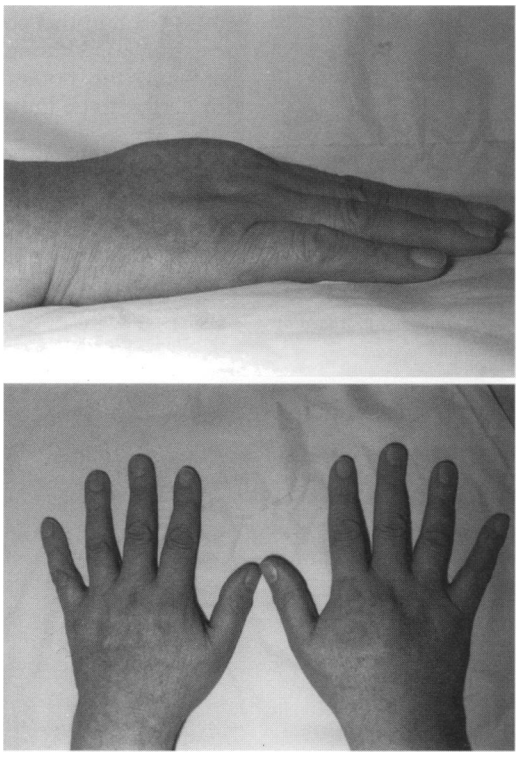

Figure 1 Haematoma secondary to the deep soft tissue injury. Just visible are the contact points of the electrodes on the skin.

ELECTRIC SHOCK BATON

This implement looks like a police baton but with two stud electrodes at one end. These are designed to be pressed against the skin. The instrument is not designed to incapacitate, but to encourage the victim to move! A variant of this design is the electric "wand" which has wires wrapped around the length, and some models incorporate both.

CATTLE PROD

Correctly termed animal "coaxers", these devices have the same basic design as the stun gun but the audible and visual warnings are of course unnecessary. There is a huge variety of design (fig 2) and seemingly no restriction on their sale. As well as "coaxing," immobilisation and even anaesthesia of cattle by electrical means is practised in some countries, but not the United Kingdom. These latter devices are necessarily large and unlikely to be used as weapons against humans.

PHYSICS

Stun guns, including the Taser, produce a peak voltage of up to 50 000 volts when discharged, in a series of short duration, high peak pulses, between 10 and 15 per second.[3] This delivers approximately 0.8 joules of energy. The batons and coaxers deliver a regular alternating current, with peak voltages very much lower at around 200 volts.[1]

The effects of these currents on the victim depends on the resistance of the skin, which depends in turn on pressure of contact, whether the skin is intact, and if it is wet. It appears that the electrical impulse is not just localised to between the electrodes, but spreads from the point of contact along channels of low resistance, that is, neurovascular bundles, throughout the body. Thus a discharge of half a second will repel the victim, but a discharge of one to two seconds will cause tetany of most of the skeletal muscle and the victim will fall. A discharge of three to five seconds will leave the victim unable to function for up to 15 minutes. Stiffness and pain in the muscles at the site are common after paralysis has worn off.[1]

Concern has been expressed as to the potential for these devices to induce ventricular fibrillation. The heart may be fibrillated by the passage of as little as 0.1 A applied for 0.5 seconds.[4] However, a larger current needs to be

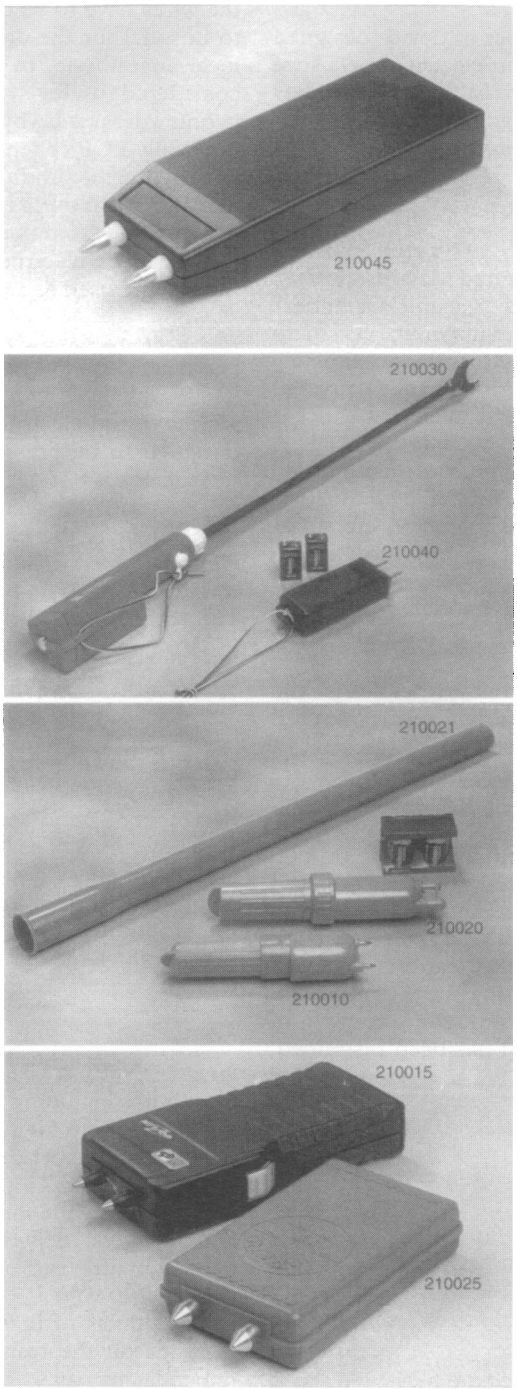

Figure 2 Animal coaxers. Photographs kindly provided by Kruuse UK Ltd, veterinary suppliers.

applied to the body as a whole for the percentage passing across the myocardium to reach this level. The energy delivered to the body by one shock from a stun gun is below the threshold for inducing ventricular fibrillation.[1] However, the effect of repeated shocks or application of the weapon directly over the heart is not known. Sudden deaths have been reported with Taser use, but although these were thought to be cardiac in origin, drug intoxication was felt to be the precipitating cause.[2] In addition, there is a risk that a person in contact with the victim will also receive an incapacitating shock.

In contrast, the discharge from cattle coaxers and shock batons is limited to the area between the electrodes. These devices therefore cause pain at the site, with possibly some very localised muscle spasm.

SUMMARY

From this patients' description, it is likely hat the weapon was not a veterinary implement, but a "stun gun." He was not incapacitated by the device as contact was brief, and the effects were limited to a localised electrical burn.

In the United Kingdom, stun guns are banned by the 1968 Firearms Act, as they are capable of discharging a "noxious thing," that is, electricity.[1] However, they were available through mail order until a test case in 1988 which confirmed their classification as prohibited weapons. Most are manufactured in the Far East and are widely available in many countries for law enforcement or personal defence.

These weapons are easily concealed and are very effective. Fortunately they are not commonly used in this country but can inflict serious injury. Although no cases have been reported, the potential exists for ventricular fibrillation to be induced by repeated shocks.

1 Robinson MN, Brooks CG, Renshaw GD. Electric shock devices and their effects on the human body. Med Sci Law 1990;30:285–300.
2 Ordog GJ, Wasserberger J, Schlater T, Balasubramanium S. Electronic gun (Taser) injuries. Ann Emerg Med 1987;16:73–8.
3 Fish R. Electric shock. Part III. Deliberately applied electric shocks and the treatment of electric injuries. J Emerg Med 1993;11:599–603.
4 Simpson K, Knight B. *Forensic medicine*. London: Edward Arnold, 1985.