

## Buzzer Ulcers

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Alarm equipment for the treatment of nocturnal enuresis is generally advocated in suitable cases by paediatricians and psychiatrists alike. No unwanted side-effects have yet been reported, even though "among the failures are a group of children who are able to sleep obliviously through the ringing of the alarm bell" (Gairdner, 1965). Recently, however, we have seen cutaneous ulceration occur in two children as a result of their not being awakened by the buzzer alarm system.

### Case Reports

*Case 1.*—A boy of 5 began using an enuresis bed in August 1962. Within two to three weeks the buzzer alarm system became faulty and on a number of occasions did not sound, even though he wet the bed. At about this time he began to develop painless ulcers in areas of skin in contact with the apparatus. The use of the bed was discontinued in November 1962. When the child was first seen in January 1963 there were circular, acutely defined scars of healed ulcers on the left buttock, right anterior costal margin, back of the wrist, and lumbar region. On the right hip there were three circular, punched-out ulcers—two of 1 cm. and one of 2.5 cm. diameter—with clean granulating bases (Fig. 1). On the back of



FIG. 1.—Case 1. Showing three ulcers on the right hip.

the right wrist there was a similar punched-out circular ulcer, the base of which was covered by a black eschar. The child, who had a habit of sleeping with the left arm above his head and the right at his side, at no time complained of his ulcers. Each one appeared rapidly, in 24 to 48 hours, and was completely painless. Complete healing occurred over the next month, though there has since been some keloid formation.

*Case 2.*—A boy aged 7 years began using an enuresis bed in June 1964. For the first two weeks his mother slept in the room and changed him immediately the buzzer sounded. For the next three weeks he slept by himself and was not awakened by the buzzer, though he wet the bed every night. The ulcers came in three crops during these latter three weeks—a single large one, a number of small ones, and a final single one. On each occasion they were not present when the child went to bed, but were fully formed the following evening when he was bathed. The last ulcer had a central black haemorrhagic and necrotic crust when first noticed. On no occasion did the child complain of pain or any other symptom:

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indeed, he did not even draw his mother's attention to the lesions. On examination there were sharply defined atrophic scars of healed ulcers on each hip, measuring 0.5 to 1 cm. in diameter, three on the left and one on the right. Two larger circular punched-out ulcers, one on each hip, were also present. They measured 2 cm. in diameter, the bases being covered by an adherent black eschar. The ulcers healed spontaneously two months after he ceased using the enuresis bed.

The symptomatology in these two cases is remarkably similar, the five salient points being that (1) all the ulcers occurred while the children were using the bed, (2) they occurred only in areas of skin in contact with the bed, (3) they appeared to occur only if the child was not woken by the buzzer, (4) they occurred rapidly, in 24 to 48 hours, and (5) they were completely painless.

### Investigations

#### Description of Unit

The complete unit is shown in Fig. 2. The blanket is made of a plastic material on to which are sewn thin strips of aluminium foil which serve as detecting electrodes. The alarm-buzzer unit (top of Fig. 2) contains a 4.5-volt dry torch battery, together with a relay and alarm mechanism (Fig. 3).

In assembling the apparatus for normal use the electrodes of the blanket are connected through a magnetic relay to the positive and negative terminals of the battery. When urine makes contact with the blanket electrodes a circuit is completed, and a flow of electric current causes the relay to close and the alarm buzzer to sound. At the same time a short-circuit device cuts off current from the blanket.

#### Experimental

Examination of the enuresis unit shows that when the voltage source from the battery is reduced from the normal 4.5 volts to 3 volts or less the current is then insufficient to operate the magnetic relay, and under these conditions it is possible to wet the blanket electrodes with urine without causing the alarm buzzer to sound. For the same reason there is also a failure to cut off the voltage supply to the blanket electrodes, and a process of electrolysis may therefore be expected to occur in any urine which happens to lie in contact. In view of the fact that the predominant electrolyte of urine is sodium chloride, experiments were made with a 0.16 M solution of sodium chloride. Two layers of filter paper soaked in sodium chloride solution were applied to the skin of the forearm, and two blanket electrodes were then pressed firmly against the filter paper. Initially a potential of 1.5 volts was connected to the blanket for periods up to 80 minutes, but no sensation of pain was experienced and no injury resulted.

When a potential of 3 volts was applied to the electrodes a tingling sensation became apparent within three to seven minutes, and after 10 minutes this became moderately painful, but no injury resulted from test applications of 10, 15, and 20 minutes' duration. Although at the end of a 25-minute period of application the skin showed no sign of erythema or injury, within the next 48 hours an ulcer some 8 mm. in

diameter appeared. The ulcer seemed to involve the whole skin-thickness, showed little surrounding inflammation, and was relatively painless (Fig. 4). In this instance the investigator was unaware of the success of the experiment, and the chance commentary of another was required to draw his attention to the lesion.

The experiment was repeated with a cathode composed of platinum instead of aluminium foil, but this change in metal made no difference to the result: after an application of current for a period of 20 minutes a crop of seven small ulcers

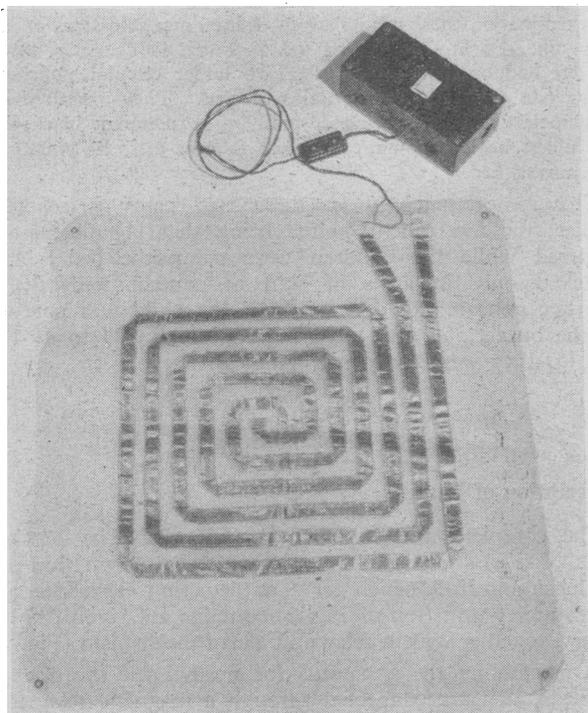


FIG. 2.—Photograph of the complete unit.

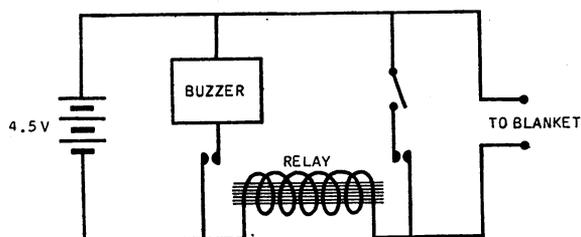


FIG. 3.—Circuit diagram of unit.

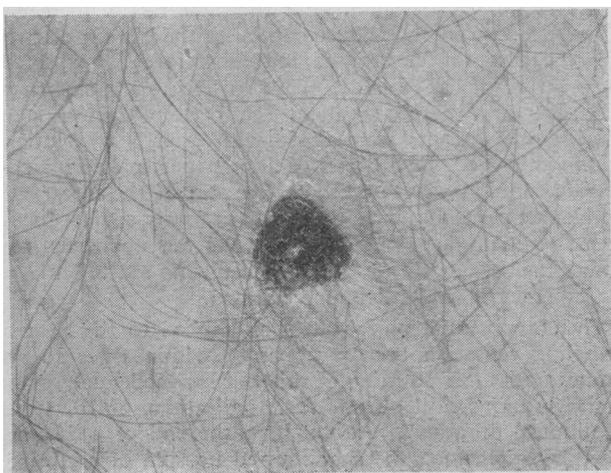


FIG. 4.—Ulcer on forearm.

appeared on the skin in an area where the cathode had been placed.

No ulceration occurred when the blanket electrodes were applied to an area of skin which had been moistened with a 0.15 M solution of sodium hydroxide.

### Discussion

From the experiments described it seems clear that, although the passage of electric current plays an essential part in producing the lesion, this is not a simple phenomenon of electrolysis over the surface of the skin.

The probable sequence of events in the production of the injury is as follows. First, soaking of the skin by a solution containing electrolytes breaks down the high electrical resistance of the stratum corneum. Secondly, a firm pressure applied to the blanket electrodes ensures good contact with the skin through a thin film of fluid which is provided by the filter paper or wet bed-linen. With the passage of current electrolysis occurs between the anode and the cathode through the moist pad of material lying on the skin, but, more important, also through the skin itself, which acts as an electrical bridge. In the migration of ions to the anode and cathode it is to be expected that the electrolytes of the intracellular and extracellular fluid must also follow this movement, with consequent disturbance of both pH and cell electrolyte distribution. On this basis the origin of cell death can be understood, and also why deep ulceration can occur so readily. It is not clear why ulceration only appears close to the cathode electrode, unless this represents a greater tissue-sensitivity to basic ions.

### Conclusions

In presenting this report of two cases of ulceration following the use of an enuresis blanket, we should also mention that to our knowledge a third case has also occurred, and we therefore wonder to what extent similar cases have occurred elsewhere. We do not wish to single out any one manufacturer's appliance as unsafe, in view of the fact that a similar principle is employed by many of the enuresis blankets currently available. Many patients can use these blankets without harm, and it is only under special circumstances that an injury is possible. There are three different ways in which a blanket can produce an ulcer: first, if a small quantity of urine leaks on to the bed in an amount too small to trigger the alarm relay; secondly, if the battery in the apparatus is used in a partly run-down condition, so that the relay mechanism is rendered insensitive; thirdly, if the sounding of the alarm fails to awaken the patient. In the latter circumstance the battery can run down until there is insufficient current to hold the relay closed; the alarm therefore stops sounding and the blanket electrodes become alive once again. In the two cases which are reported here it was either the second or the third mode of injury which was probably responsible for the ulcers.

### Summary

Two young patients developed an unusual type of skin ulceration after the use of enuresis-alarm apparatus.

The origin of this ulceration has been investigated and has been reproduced experimentally. The ulceration is believed to be due to direct current electrolysis occurring through moist skin.

It is probable that similar cases of skin ulceration may now be occurring when these enuresis blankets are used, so that there is a need to alter the electrical design of these alarm systems.

### REFERENCE

Gairdner, D. (1965). *Brit. med. J.*, 2, 91.