USE OF A RADIO TRANSMITTER RECEIVER UNIT FOR THE TREATMENT OF NEUROGENIC BLADDER

A PRELIMINARY REPORT*

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Urinary sepsis, secondary to neurogenic vesical dysfunction associated with trauma of the spinal cord, is a well recognized clinical problem. Prolonged use of indwelling catheters in paraplegic patients produces significant bacteriuria, cystitis, vesicular calculi and pyelonephritis. Kass and Sossen have shown that use of an indwelling catheter for 24 hours results in bacteriuria in 50 per cent of patients, and in 98–100 per cent of patients after 4 days. With antibiotic therapy and closer attention to rehabilitation of the bladder during and after World War II, mortality rate in paraplegics from urinary sepsis has declined. However, of approximately 746 veterans with spinal-cord injury who died during the period of 9 years following World War II, death was attributed to urinary-tract infection in 64 per cent. In another series of patients urinary-tract damage was found in 65 per cent dying from other causes.

Ruch, in a review of the physiology of micturition, described bladder tonus or the response of smooth muscle of the bladder to the stretch imposed by filling (shown in the slowly ascending limb of a cystometrogram) as an intrinsic property of smooth muscle and not reflex in nature. Changes in this phase of the cystometrogram are shown to follow physical alterations in the tissue of the bladder. Regular, complete evacuation of the neurogenic bladder with avoidance of infec-

tion and damage of the tissue therefore would aid in preserving normal tonus and facilitate rehabilitation of function of the bladder. Electrical excitability of the mammalian bladder has been demonstrated in vivo and in vitro. Since electrical excitability was undiminished in the isolated-bladder preparation, it might be expected that bladders in situ would be responsive after spinal-cord section.

In view of these findings, it seemed feasible to attempt emptying of the neurogenic bladder by electrical stimulation and avoid the use of urethral catheters. In the following experiments, electrical parameters were determined for emptying the bladders of paraplegic dogs, and the use of an implanted receiver-stimulator triggered by a detached, external radio transmitter was studied.

METHODS

Acute Experiments. Twenty mongrel dogs, 10 males and 10 females, weighing 10–12 kg., were used. Following transection of the spinal cord at the cervicothoracic junction under brief ether anesthesia, the right ureter was exposed using a suprapubic incision. Polyethylene T-tubing was inserted into the cut ends of the ureter and passed into the bladder. The pressure responses of the bladder then could be recorded during stimulation and emptying using a pressure transducer and continuous graphic recorder. Filling of the bladder was aided by intravenous water loading of 5 per cent dextrose in water. Using this method, urethral catheters were avoided and the normal function of the urethral sphincters was preserved. Continuous blood-pressure recordings were made from the femoral artery. Period of spinal shock lasted about 1 to 2 hours. Experiments were terminated at 4 to 6 hours.


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Stimulating electrodes of stainless-steel discs 0.5 cm. in diameter were used. Using a Model Grass III* stimulator, bipolar, monophasic and biphasic stimuli were applied to the bladder and optimal-stimulation parameters were determined for emptying.

Chronic Experiments. A total of 31 mongrel dogs, weighing 10–12 kg., were used. Spinal cord was transected at the C8-T1 level in 24 dogs. The cauda equina below the level of the 7th lumbar vertebra was destroyed in 2 dogs. Five control dogs, without neurological injury, were implanted with a receiver and electrodes to test reaction of tissue over a period of 3 months. Receiver and electrodes were sterilized by overnight immersion in tincture of Zephriran and washed with sterile saline. The receiver was implanted subcutaneously as shown in Fig. 1, lateral to the sheath of the rectus muscle, using interrupted silk sutures. Two to six connecting electrodes were attached to the external surface of the fundus of the bladder using interrupted silk sutures sewn through the outermost layer of the wall of the bladder. Electrodes were placed on the anterior and posterior surfaces of the fundus in its superior portion. In the dog it was difficult to implant the electrodes extraperitoneally.

Bladders were emptied at 4 to 8 hourly intervals using the radio transmitter to trigger the receiver-stimulator. Stimulation periods ranged from 1 to 3 min. Urine was collected and measured and frequent estimations of residual urine were made. Cystograms and cineroentgenologic films were made before, during and after evacuation of the bladder following instillation of a radio-opaque dye.

Antibiotics were given during the first week postoperatively and discontinued after removal of sutures in the skin. In some dogs control cultures of urine were made pre-operatively and after discontinuation of antibiotics. Postoperative hypotension occurred in some animals and was treated with intramuscular Neo-Synephrine. Plaster body casts were used to prevent the development of decubitus ulcers. Dogs were sacrificed and autopsied at intervals of 1 week to 3 months. Bladders and kidneys were saved for gross and histologic examination.

Instrument. The transmitter, receiver and electrodes shown in Fig. 2 were designed in association with Medtronic Inc., Minneapolis. The transmitter is of conventional design. The signal is transmitted by a flat, circular-loop antenna held 1 to 2 inches from the skin directly over the receiver. A timer may be used to trigger the transmitter every 4 hours for a period of 3 min.

The receiver is round, approximately 6 cm. in diameter and 1.5 cm. at its greatest width. It is coated with nonirritant material. No battery supply for receiver is required. Power for the receiver output is derived from the transmitted signal. The transmitter requires power supplied by the alternating current mains. The receiver is tuned to the transmitted signal. The transmitted signal is altered by the receiver components and the stimulus is applied to the electrodes on the bladder. The wires connecting the receiver output to the bladder are coated with the same nonirritant insulating material as the receiver. Electrodes consist of stainless-steel circular discs, 0.5 cm. in diameter, embedded in an insulating material base. Two to four leads may be connected from the receiver to the bladder, depending upon the size of the bladder.

RESULTS

Acute experiments showed that optimal stimulating parameters of 10–15 volts peak to peak, 1–5 msec. always resulted in complete emptying of the bladder both during

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* Grass Instrument Company, Quincy, Massachusetts.