Acta Urol. Jap. Vol. 21
No. 3, March 1975

IMPLANTABLE ELECTROSTIMULATOR FOR URINARY BLADDER: ANIMAL EXPERIENCES NINE MONTHS LATER

Atsuo KONDO

From the Department of Urology, Nagoya University School of Medicine, Nagoya 466, Japan

It is believed that the smooth micturition without residual urine aided by electrostimulation would be of great benefit for a cord bladder patient, which would preserve renal function good and prolong his life. Three sets of implantable electrostimulating devices were developed* and had been implanted for the past nine months. It seems that the suitable sites to stimulate and the parameters of electric current have been established[1~3]. The tonic spasm of pelvic floor and lower extremities at the time of stimulation remained to be solved in the future.

Methods and Materials

Three female mongrel dogs (21 kg to 26 kg) were used for implantation under the pentobarbital anesthesia. When succinylcholine chloride (SUCCIN, Yamanouchi), 40 mg to 60 mg, was injected intravenously, the respiration was mechanically assisted (Aika Respirator, R-60). The intravesical pressure was recorded via a small plastic tube (O.D.=1.0 mm) placed in urethra, and then connected to an electromanometer (RM-20, Nihon Koden). Urinary flow rate was monitored with Mictiograph (14F43, DISA). A chest bellows was applied around the thorax.

The implantable stimulator consists of 3 parts; (i) internal receiver from which six stainless steel wires and disk-typed electrodes, 9 mm in diameter, derive, (ii) power transmitter containing nickel-cadmium rechargable batteries, and (iii) battery charger (Fig. 1). When the power transmitter is in direct contact with the receiver, the maximum voltage, 17 volts, is induced with 33 Hz and 4 msec duration of biphasic square wave. Through a suprapubic midline incision, six electrodes were fixed above vesical serosa in the manner of two circles between ureterovesical junction and

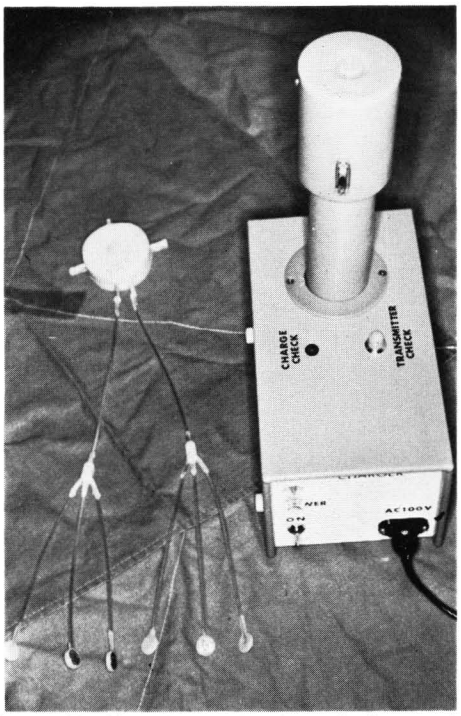

Fig. 1. Bladder electrostimulator device consists of implantable internal receiver, external power transmitter and batter charger.

* Tokai Rika Corp., Nishibiwazima-cho, Nagoya-shigai 452, Japan.

bladder apex[4]. The internal receiver unit, all shielded with Silastic elastomer and tubes (Dow Corning) except one side of electrode facing the detrusor muscle, was fixed to the aponeurosis of external oblique muscle subcutaneously. Episiotomy was performed at the same time.

Results

The results observed in three dogs were tabulated in Table 1. The apparatus has been working quite satisfactorily for the past 9 months in one dog. The others stopped functioning at 5 and 8 weeks later

Table 1. Results of 3 dogs which have had electrostimulator implanted. Animal experiments were carried out under pentobarbital anesthesia. Values in parentheses observed when succinylcholine was used.

DOG #-Sex-weight	Acute experiment	6 weeks later	9 months later
36-F-25.5 kg	RR*: 60%, poor	RR: 40%***, fair	(−)
38-F-21 kg	RR: 0%, good	RR: 0%, good	RR: 0%, good Peak flow rate: 15 ml/sec (14 ml/sec) Ave. flow rate: 8.8 ml/sec (10.8 ml/sec)
39-F-26 kg	RR: 0%**, good	(−)	(−)

*: Residual rate, residue over pre-voiding capacity.
**: Non-functioning 5 weeks later.
***: Non-functioning 8 weeks later.

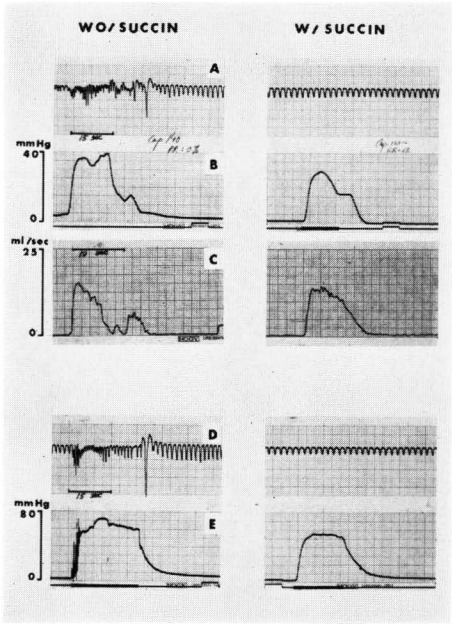

Fig. 2. Recordings A, B and C represent isotonic study and D and E isometric study observed 9 months later in dog #38. B and E: intravesical pressure. C: urinary flow rate. A and D: respiration. Experiment was performed under pentobarbital anesthesia. Curves of left half were observed without succinylcholine and right half with succinylcholine.

respectively. Micturition started as soon as the bladder was stimulated. The maximum intravesical pressure during voiding was 39 mmHg with partially interrupted urinary stream, while the peak of urianry flow rate was 15 ml/sec. Residual urine was not found. In the isometric study the maximum pressure elevated up to 72 mmHg, sufficient enough to overcome the urethral resistance (Fig. 2).

Though succinylcholine, neuromuscular blocking agent, cleared off the spasm of skeletal muscle, the maximum intravesical pressure in both isometric and isotonic studies lowered by 22 to 25%. The peak flow rate was scarcely affected and the average flow rate was, on the contrary, improved by 14%. No foreign body reaction is presently found around the receiver implanted in dog #38.

Discussion

The apparatus ceased functioning due to the short-circuit inside the receiver, which was caused by the invasion of tissue fluid. An improved model with a more water-tight structure is indicated, which is now under experimentation.

Hald and Mygind[5] demonstrated in dog bladders that the skeletal muscle relaxant increased the urethral diameter during voiding but lowered the maximum isometric and isotonic pressure in denervated bladders. They also noticed that the average urinary flow rate, though only a few ml per sec, decreased and that the residue increased in two out of three dogs. In the present study the urinary stream became uninterrupted and no residue was found after succinylcholine, whose mode of action was said to be the initial depolarization followed by desensitization to acetylcholine. Furthermore the minimum urethral resistance[6] was improved from 0.23 unit to 0.19 unit. The relaxed pelvic floor muscles seem to have chiefly contributed to lessen the urethral resistance. This postulation finds support in the observation reported by Abe[7]. The inconsistant result would be explained by their inadequate experimentation to stimulate detrusor and pelvic nerve.

An unanesthetized dog voided urine with electrostimulation always accompanying an apparent painful agony and tonic spasm of lower extremities and pelvic floor. The spread of electric current to the adjacent nerve fibers seems to be responsible. This experiment should be further studied in a denervated dog in the future.

Summary

Three sets of electrostimulator device have been implanted in female dog bladders. One of them has been working quite satisfactorily during the past nine months. The others stopped functioning 5 and 8 weeks later respectively, which was caused by a short-circuit inside the receiver. The maximum voiding pressure elevated up to 39 mmHg and the maximum flow rate 15 ml/sec. The urinary stream was partially interrupted and the average flow rate was calculated 8.8 ml/sec. Residual urine was not found. In the isometric study the pressure rose up to 72 mmHg. Though succinylcholine cleared off the muscle spasm and decreased the maximum pressure in both isometric and isotonic studies, the urinary flow became uninterrupted and improved as a whole. Durability of the device should be further studies and improved, and clinical application of this method is indicated in a near future.

Acknowledgement

The author is thankful to Dr. Mitsuya, director of department, for his continuous interest, and to Mr. Yamamoto for his excellent technical assistance.

References

1) Susset, J. G. and Boctor, Z. N.: Electrical stimulation of the bladder. An experimental study. Invest. Urol., **5**: 20, 1967.
2) Halverstadt, D. B.: Electrical stimulation of the human bladder. 3 years later. J. Urol., **106**: 673, 1971.
3) Kondo, A., Matsuo, K. and Torii, H.: Micturition aided by electric stimulation. Relationship of efficiency to the site of stimulation. Acta Urol. Jap., **19**: 589, 1973.
4) Kondo, A.: Micturition aided by electric stimulation. A subchronic study. Acta Urol. Jap., **19**: 853, 1973.
5) Hald, T. and Mygind, T.: Effect of curare on canine micturition. J. Urol., **97**: 101, 1967.
6) Susset, J. G., Rabinovitch, H. H., Rosario, F. and MacKinnon, K. J.: Measurement of urethral resistance, J. Urol., **96**: 746, 1966.
7) Abe, N.: Studies of electro-stimulation of the bladder with lower motor neuron lesion of the spinal cord. Jap. J. Urol., **60**: 1143, 1969.

(Accepted December 16, 1974)

要　約

体内植込み装置による膀胱電気刺激：9カ月後の実験成績

名古屋大学医学部泌尿器科学教室（主任：三矢英輔教授）
近　藤　厚　生

膀胱電気刺激装置（体内受信器と刺激電極，体外発信　　装置，電池充電器）を開発し，メス成犬による実験

を試みた．2頭に植込んだ装置は，5週および8週後にそれぞれ作動不能となったが，残る1頭は9カ月後も電気刺激によく反応し，満足すべき成績が得られた．すなわち最大排尿率 15 ml/sec，平均排尿率 8.8 ml/sec，排尿時最大膀胱内圧は 39 mmHg であった．骨格筋痙攣のため尿線は一部分中断したが，残尿は 0 ml であった．

筋弛緩剤投与 (succinylcholine chloride) により，痙攣は消失し，尿線および排尿状態は改善した．今後さらに装置の耐久性，生体反応の有無などにつき観察を続け，臨床例に応用すべく研究をつづけている．