TREATMENT OF DEMYELINATING AND DEGENERATIVE DISEASES BY ELECTRO STIMULATION OF THE SPINAL CORD

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INTRODUCTION

Physicians initially learned the function of various portions of the nervous system by attempting to correlate the clinical observations noted during the lifetime of the patient with the findings of the postmortem examination. In the last century, the function of different areas of the nervous system were studied in the experimental laboratory by either removing or stimulating that area in the experimental animal, and recording the changes which were observed.

As neurological surgery developed in this century, it was possible to evaluate the results of function of part of the nervous system after surgical extirpation of that area in man. Now physicians are able to learn not only the effects of removal of nervous tissue in man, but also to learn the effects of stimulation of particular portions of the nervous systems of man.[1,2]

METHODS

Until recent years, electrical stimulation of the spinal cord required general anesthesia and laminectomy. Therefore, those patients who were felt not to be suitable risks for this type of surgery did not have electrostimulation of the spinal cord. The development of the percutaneous technique for applying electrical stimulation to the spinal cord, or nerve roots, has made that procedure more readily available for a larger number of persons.[3] This percutaneous technique is performed under local anesthesia, which is more benign than the operative procedure. The percutaneous technique is accomplished by placing two (2) thin walled #16 gauge Touhy Needles into the spinal epidural space, and threading electrodes through these needles.* The electrodes are positioned so that the patient feels the stimulation in the appropriate areas, whether this be for pain or for demyelinating or degenerative diseases.

It has been the custom to do this procedure in two (2) stages. The first stage is the testing one, and the electrodes are put in position and connected to a Percutaneous Transmitter. If improvement in signs and symptoms are noted after stimulation of three (3) to four (4) days, then the permanent electrical stimulating system is installed and the current maintained by radiofrequency transcutaneous coupling.

*Medtronics, Inc., Minneapolis, Minnesota; Avery Laboratories Inc., Farmingdale, Long Island, New York.

INSTRUMENTATION AND DATA

The instrumentation employed for measuring threshold current, voltage, and pulse duration is shown Diagram 1. Energy, resistance, and microcoulombs were calculated. The portable TEKTRONIX 214 Dual Channel Storage Oscilloscope was the monitor. The stimulator amplitude control was brought to threshold of patient perception for recording and measurement. Average values of current and voltage were estimated from the photographs, including simultaneous traces of each.

Single and dual exposure percutaneous spinal implantable electrodes, manufactured by Medtronic, Inc., were employed. The platinum surface area was 4 and 8 sq mm respectively, with a lead resistance of 100 Ohms.

In the 11 cases sampled for measurement, the largest threshold energy required was a stimulus of 26μJ, giving an average energy at 33Hz of 870μWatts. The minimum average energy was 77μW with the mean threshold at 33Hz being 450μW.

Electrode resistance ranged from 423 Ohms to 2500 Ohms, with an average of 1KOhm.

The threshold charge ranged from 0.8μCoulombs to 4.4μC, with the average required for perception being 2.0μC.

The electrodes were positioned in the epidural space without "jamming" against the laminae. Variations in the precise geometry and shunting medium were probably the major contributing factors to the wide range of threshold values for these electrode placements.

The portion of electrical energy reaching the spinal cord is unknown. It is well known from clinical experience that electrodes in the subarachnoid space have thresholds of stimulation a fraction of that for electrodes sewn between the leaves of the dural, which are still less than for the electrodes in the eipdural space. There was no correlation between the threshold nor the distance between electrodes and the change in neurological status of the stimulated patients.

Thus far there has been no evidence that electrical stimulation of the spinal cord, applied between dorsally placed percutaneous electrodes and at levels of perception of paraesthesias, has any effect on neurological function.[4]

Spinal cord dysfunction, which was reversed when the stimulation was turned off, has been observed in association with electrical energy delivered by five (5) in-line electrodes implanted in the subdural space by a laminectomy. The current delivered by this array of electrodes is more dense than that of the percutaneous system. Histological examination of the spinal cord showed no changes secondary to long term application of the electrical current.[7]

PRESENTATION OF PATIENTS

During 1975, 1976, and 1977, electrodes were placed in the spinal epidural space of 78 patients with various disorders of the central nervous system, which had not been responsive to standard therapeutic measures. (Chart 1) Sixty-one patients had Multiple Sclerosis, two (2) Olivopontocerebellar Atrophy, one (1) Amyotrophic Lateral Sclerosis, one (1) Primary Lateral Sclerosis, one (1) Transverse Myelitis, 10 Ataxia and three (3) had sustained Spinal Cord Injury. The patients were evaluated by Medical Neurologists, by members of the Department of Physical Medicine and Rehabilitation, the Department of Urology, and by Videotape Movies.

EVALUATION RESULTS IN PATIENTS WITH MULTIPLE SCLEROSIS

Thirty-seven patients showed improvement in neurological function. (Chart 2) Seven (7) of these patients had diminution of Ataxia, so they were better able to perform such tasks as feeding themselves, buttoning their clothes, and turning the dials of the transmitter, which are things they had not been able to do without the electrostimulation. Seven (7) other patients had improvement in various modalities of sensation, such as: Proprioception, Vibratory Sensibility, and the ability to distinguish between sharp and dull stimuli. Twenty-eight patients had increase in voluntary motor function of one (1) or more extremities, which enabled them to walk with less support or for longer distances and to be better able to care for their personal needs.

Reversion to pre-stimulation level of function occurred within the first two (2) weeks of installation of a permanent stimulating system in patients numbers 4, 5, and 22. The evaluation that these patients were improved by the stimulation was in error. Three (3) patients did not receive adequate stimulation. One (1) patient, who receives adequate stimulation, has had deterioration of nervous system function which began with a systemic infection. Another patient, who has adequate stimulation is worse and presumably is in an exacerbation of the disease.

Three (3) patients became worse in regards to voluntary motor function of one (1) or more extremities during placement of electrodes. The electrodes had to be repositioned in all of these patients, and the worsening occurred during the repositioning procedures. Two (2) of these persons recovered to their preoperative neurological status.

RESULTS IN PATIENTS WITH ATAXIA

Six (6) of the 10 patients with Ataxia were observed to have an increase in function of the central nervous system. Half of these patients suffered from Friedreich's Ataxia, and half from Cerebellar Ataxia. Five (5) of these individuals had less ataxia and/or voluntary motor deficit, so that they

were able to significantly enjoy a somewhat better lifestyle. Particularly notable was improvement in head bobbing and truncal ataxia in two (2) sisters with this malady. No patient was made worse during this electrostimulation. One (1) of the patients who did not improve had the system removed a year later, when he developed infection around the electrical stimulating system during an episode of systemic infection. It is emphasized that this is not a curative procedure for this disease process, since the cause for these disorders continues to mystify us.

RESULTS IN PATIENT WITH LATERAL SCLEROSIS

The one (1) patient with Primary Lateral Sclerosis has done remarkably well. Initially it was impossible to place the electrodes in the optimum region, that is the upper thoracic area. He noted improvement in his lower extremities with placement of electrodes in the lower thoracic region, and then the stimulating system did not function when the electrodes came out of position. He was readmitted and another effort made to place these electrodes in the upper thoracic region. This was successful on this occasion, and with stimulation in all extremities, he has continued to do extremely well. It is now approximately two (2) years after the initial procedure, and he continues to improve.

RESULTS IN PATIENT WITH TRANSVERSE MYELITIS

This patient had improvement to the extent that he was alleviated of over 75% of pain in his lower extremities, and his feet were not held in flexion. He was able to put his feet flat on the ground to walk better with his crutches. The electrodes have slipped out of position, and he no longer has adequate stimulation. He again has the pain in his lower extremities, and he walks on his toes. Thus far, he has elected not to have the electrodes adjusted.

RESULTS IN PATIENT WITH AMYOTROPHIC LATERAL SCLEROSIS

This patient had no significant change in his neurological status, and has had progressive neurological dysfunction since first examined.

RESULTS IN PATIENTS WITH OLIVOPONTOCEREBELLAR ATROPHY

One (1) of these patients had improvement in his neurological status to the point that he was able to button his clothes and turn the dials of the transmitter. He had not been able to do either of these things without the electrical stimulation. He died of a myocardial infarction a few months after installation of the stimulation system. The other patient with Olivopontocerebellar Atrophy had no significant changes in neurological status.

RESULTS IN PATIENTS WITH SPINAL CORD INJURY

Two (2) patients with spinal cord injury had significant improvement in neurological status, but this was not in a manner which benefited them and their lifestyle. One (1) patient only had changes in sensation, whereas the other had increase in voluntary motor function of the lower extremities. However, the spasticity was so overwhelming that the increase in voluntary motor function did not help his gait.

EFFECTS OF ELECTROSTIMULATION ON BLADDER FUNCTION

Thirty-nine patients, all of whom had significant urinary symptoms on a neurogenic basis, were evaluated for the effects of electrical stimulation of the spinal cord on the urinary tract.

Eight (8) patients had hypotonic bladders, and thirty-one persons had hypertonic bladders. It was not possible to keep the electrodes in position in patient #49, who had a hypotonic bladder, and therefore it was not feasible to evaluate this patient.

All of the remaining seven (7) patients with hypotonic bladders noted at least a 50% diminution of urinary frequency and incontinence. The urgency time was also prolonged over the pre-stimulation urgency time. Four (4) of these persons, #2, #3, #20, and #25 had residual urines of over 100cc, which came down to under 60cc with electric stimulation. Only patient #13 did not have a drop in the residual urine, but this patient also had a residual urine of 60cc which was at the borderline of normal. All of these patients noted improvement of symtoms after three (3) to four (4) days of electrostimulation. The residual urines were measured at that time and again on discharge.

Five (5) of the 31 patients with hypertonic bladders had better control of urination with electrostimulation of the spinal cord. The improvement in symptoms did not occur as quickly as it did in the patients with hypotonic bladders. The improvement in urinary symptoms were observed by the patients and their families to be less severe beginning after several weeks of electrostimulation, and patient #25 noted this improvement during the first week of stimulation. Again, the return of residual urine to normal limits was predictive of increase in urinary tract function. None of the patients who did not improve had any decrease of residual urine.

Six (6) of the patients who improved experienced technical difficulties, so that they did not receive adequate stimulation. Their neurological symptoms, including bladder function, regressed within a few days and residual urines climbed to several hundred cc. Five (5) of these patients elected to have the current re-established, and again an improvement of symptoms and decrease in the volume of residual urine were noted.

It is hypothicated that the electrical energy which was applied to the thoracic spinal cord was effective because it enhanced the autonomic influences on the urinary tract. There is data which suggests that there are noradrenergic pathways which are altered by electrostimulation.[5,6]

All of these patients have continued to enjoy the changes in bladder function except patient #25. She had had a general deterioration of health and central nervous system function since a viral infection. She now has a indwelling catheter, and is severely quadriplegic.

DISCUSSION

The concept that patients with Multiple Sclerosis and Ataxia can be treated by neurosurgical intervention is unique. Like all new concepts, it needs to be critically evaluated by several individual investigators. The results in this publication are generally in agreement with the pioneering efforts of Cook.

Experience indicates that the patient who is paraplegic is most unlikely to regain any useful function in the lower extremities with electrical stimulation. However, this individual might have less spasticity, and/or pain, which could enable him to function better. The patient who is paraplegic and is impaired by Hypotonic Neurogenic Bladder, or Ataxia, or mild motor deficit of the upper extremities may show improved function of the upper extremities and bladder with electrical stimulation. The patients with these anatomical findings are candidates for the testing procedure. Patients whose neurological examination indicates mild impairment of function have a much greater expectation of aide by electrical stimulation of the spinal cord. Significant enhancement of neurological status in the patients reported in this publication is around 50%. Thirty-two out of 44 patients who were ambulatory had enough improvements in their neurological status so that they were better able to function in activities of daily living. However, only 10 out of 19 patients who were not ambulatory had any improvement in neurological function.

All of these patients were examined by at least four (4) examiners. One (1) of these examiners was concerned with direct care of the patient, and the other three (3) tried to be as objective as possible in their appraisal of the patient's neurological function before and during electrical stimulation. Special emphasis was placed on assessment of bladder function, since it was felt that these studies were an objective measurement of neurological disturbance.

An argument could be made that patients with Multiple Sclerosis had a remission of symptoms at the time stimulation was applied. This seems to be statistically unlikely. The observation of worsening of symptoms and signs without stimulation, and restoration of function when stimulation was

re-established refutes this contention.

The patients reported many changes in symptoms during the electrical stimulation, but unless some objective finding could be observed, that change was not recorded as an improvement. Some patients were observed to have minor changes in motor and sensory function, but again, these are not recorded in this publication. It is important to distinguish between betterment of neurological examination, and changes which enable the patient to function in an improved lifestyle. For example, the regaining of strength of muscles which does not improve the patients gait, or enable him to walk better, is not considered by that individual to be of any benefit to him. That is the reason that the patients who showed improvement are divided into categories of those who enjoyed a better lifestyle with stimulation, and those who did not do so.

Expectations of patients who have been told there is no treatment for their disease are high when a new therapy is announced. Many naturally anticipate a total rehabilitation from their plight. Misconceptions about this particular treatment are many, and a few patients think all they have to do is push a button, and they can get up and walk. Nothing could be further from the truth. Electrical stimulation of the spinal cord can be likened to a cardiac pacemaker. A cardiac pacemaker does not cure the basic disease process. But, it does help the heart to work better, and the patient needs to follow-up with rehabilitation after the installation of a cardiac pacemaker. Likewise, the spinal cord pacemaker helps the nervous system work better, and the patient needs to do his part by keeping the system functioning, and following up with rehabilitation. Patients who are poorly motivated and expect the stimulator to do everything for them are unlikely to be happy with this form of treatment. The difficulty is screening out these poorly motivated people, since almost all patients will say that they understand the procedure and will follow-up with all recommendations. When the results are not all they desire, they will not turn on the stimulator. Then they receive inadequate stimulation, and the money and efforts of many people have been wasted.

Patients with certain personalities are content with a major disability, and are ill-prepared to adjust to a lifestyle in which they are less dependent on others. The patients of this type usually will not use a stimulator as prescribed, nor will they follow-up with rehabilitation. Indeed, a few of the patients reported in this publication vigorously fought the concept that they were able to better perform certain functions, whereas it was readily apparent to observers and to members of the family that they were able to do so.

It is hypothecated that the application of electrical current to the spinal cord alters the equilibrium of neurotransmitters concerned with function of neural pathways. Current investigative work indicates that electrical stimulation will alter the activity of various neurotransmitters. The neuro-

transmitters affected by electrical stimulation of the spinal cord, and the mechanisms by which they change the function of the nervous pathways in disease states, is unknown at the present time.

This publication seems to indicate that certain patients who are well motivated, and who are disabled from their usual activities by demyelinating and degenerative diseases of the nervous system, are candidates for electrical stimulation of the spinal cord. It is emphasized that this should be performed in two (2) stages. The first should be the testing procedure for thorough evaluation of the neurological function, with and without stimulation. If no significant changes in function are observed, then it is unlikely that they will occur with stimulation over several months. However, one (1) of the patients who did not improve with the testing stimulation, did improve much later with chronic stimulation. Permanent electrical stimulation of the spinal cord without the testing procedure, which can be easily performed, has not been utilized by the authors of this publication.

SUMMARY

Electrical stimulation was applied to the spinal cord of 75 patients who had demyelinating and degenerative diseases of the central nervous system, and three (3) patients who had sustained spinal cord injuries. The electrical energy was delivered to the central nervous system by the percutaneous technique.

The amount of electrical energy required to produce the perception of paraesthesias was measured in eleven patients. The minimum power necessary was 77μW, the maximum was 870μW, and the average was 450μW.

The patients were evaluated by four (4) examiners by means of routine neurologic examination, videotape movies, and measurement of urinary bladder function. Continued improvement in neurological status, which allowed the patient to live a better lifestyle, occurred in 30 of the 61 patients with Multiple Sclerosis, and six (6) of the 10 patients with Ataxia. The patient with Transverse Myelitis, the patient with Primary Lateral Sclerosis, and one (1) patient with Olivopontocerebellar Atrophy; also noted similar enhancement of neurological function. The patients with Amyotrophic Lateral Sclerosis and Spinal Cord Injury had no changes of significance.

Thirty-two out of 44 patients who were ambulatory had significant improvement, whereas 10 of the 19 patients who were not ambulatory had improvement.

There was no evidence that electrical stimulation of the spinal cord, when applied via dorsally placed percutaneous electrodes, and when carried only to the perception of a paraesthesias, has any adverse effect on neurological function.

It is hypothecated that the electrical current alters neurotransmitters to enhance the transmission along nervous and neurochemical pathways. The exact mechanisms are unknown at the present time.

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Diagram 1: Stimulation Schematic

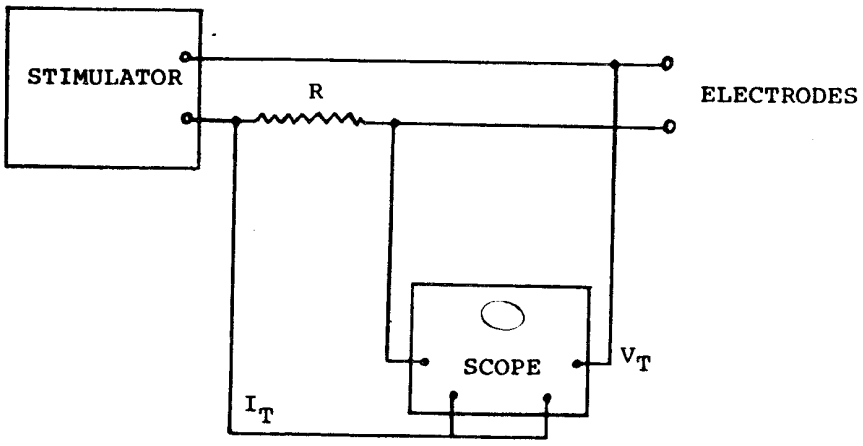

CHART #1

IMPROVED PATIENTS WITH MULTIPLE SCLEROSIS

PATIENT	SIGNIFICANT CHANGES IN LIFE-STYLE	FOLLOW-UP STATUS
#2 V.H.	Continent of urine; able to feed self	Died, aspiration pneumonia 27 mos.
#3 L.K.	Continent of urine	Quadriparesis 27 mos.
#4 I.P.	Improvement in monoparesis for one week only - probably error in judgement.	Paraparesis same. Incontinence same.
#5 D.S.	Lessening of spasticity was mild and transient.	Quadriparetic, Ataxic, Incontinent.
#6 C.S.	Dysarthria still less when stimulation used.	Quadriplegia, Incontinent.
#7 D.W.	Less abnormal involuntary movement and Ataxia enable patient to feed and dress self.	Paraparetic, Cystostomy.
#8 M.M.	Inadequate stimulation; control of urine & absence of pain in lower extremities.	Paraparetic
#9 J.J.	Ambulates better with less Hemiparesis; uses cane and rarely wheelchair.	Hemiparetic
#13 B.O.	Ambulates longer & better with canes; Progressive weakness of uppers; electrode T8; no urine dribbling.	No urine dribbling; Quadriparetic
#19 R.L.	Organic Mental Syndrome progressive; unable to use improved function lower extremities.	Paraparetic; Mental Syndrome.
#21 H.B.	Does not use stimulation; emotional & Organic Mental Syndromes; less Ataxia when stimulator used.	Quadriparetic, Ataxic, Dysarthric Mental Syndromes.
#22 C.J.	Lessening of monoparesis transient; inadequate stimulation.	Quadriparetic, Incontinent.
#25 M.W.	Electrodes moved; repositioned 3 times; Progressive Quadriparesis, Incontinence; Dysarthria still significantly less.	Quadriparetic, Incontinent.
#26 D.H.	Increase in function not sufficient to enable patient to do anything better.	Paraparetic

CHART #1

PATIENT	SIGNIFICANT CHANGES IN LIFE-STYLE	FOLLOW-UP STATUS
#27 J.K.	Progressive improvement in walking; Swims 40 laps/day; Uses stimulator 4 hours daily.	Mild Paraparesis
#28 P.E.	Increased function enables patient to feed & dress self and ambulate with less effort.	Quadriparesis
#29 S.H.	Continence of urine; ambulates better with less effort.	Paraparetic
#30 M.K.	Improved function in lower extremities has not changed her life style.	Paraparetic, uses wheelchair.
#31 A.H.	Upper extremities not flexed across chest; Dyspnea less severe; no change in functional status.	Quadriplegic, Dysphagic, Arthric.
#35 B.S.	Increased function in lower extremeties enables patient to work full time; control of urine.	Ambulates without aide, mild Paraparesis.
#36 C.K.	Progressive Paraparesis; no change in urine symptoms as first noted; inadequate stimulation.	Paraparetic, urinary urgency, Incontenent.
#39 R.B.	Increased control of one lower extremity and control of urination.	Paraparetic, less urinary symptoms.
#40 S.T.	Inadequate stimulation; progressive Hemiparesis; no change in life-style.	Hemiparetic; Emotional Syndrome.
#43 J.V.	Increased motor function enables her to be more active with less effort.	Paraparetic; less spasticity.
#49 V.C.	Increased motor function lower extremities; control of bladder.	Quadriparetic
#50 B.B.	Ambulates with less effort; improved function in daily living activities.	Quadriparetic
#56 R.H.	Inadequate stimulation; emotional mental syndrome; progressive downhill neurological status.	Paraparetic, Ataxic, Nursing Home.
#57 H.V.	Mild changes in ambulation have not changed patient's life-style.	Quadriparetic, Organic Mental Syndrome.

CHART #1 Page 3

PATIENT	SIGNIFICANT CHANGES IN LIFE-STYLE	FOLLOW-UP STATUS
#58 J.M.	The increase in function of left extremities has not changed life-style.	Hemiparetic; in same employment.
#61 I.H.	Walks further with less effort.	Paraparetic; walks independently.
#63 E.A.	Increased motor function lower extremities has not helped due to severe spasticity.	Paraparetic; walks with crutches.
#64 H.L.	Excellent increased function in gait with less motor deficit & spasticity.	Ambulates independently.
#68 C.B.	Walks longer distances without foot drop brace & with less effort.	Almost normal gait.
#69 L.R.	Walks further with walker; better use extremities & 90% relief of pain in back and lower extremities.	Ambulatory with walker.
#70 J.R.	Walks with less effort over longer distances.	Uses less walking aides.
#72 W.S.	Able to feed self & care for personal needs with stimulation; no stimulation now & improvement has regressed.	Wheelchair, poor control of uppers.
#74 P.M.	Better able to feed self and transfer.	Wheelchair.
#75 R.S.	Continent of urine; less urinary urgency, frequency & ambulates with less effort. Electrodes revised; exacerbation of disease; symptoms & signs worse without stimulation.	Paraparetic.
#77 B.V.	Less lethargy; increased physical activities due to better voluntary motor power all extremities.	Wheelchair & Walker.
#78 C.M.	Increased function right upper extremity so that he can better perform activities of daily living.	Wheelchair; good use of upper extremities.

CHART #2

IMPROVED PATIENTS WITH ATAXIA

PATIENT	TYPE	SIGNIFICANT CHANGES IN LIFE-STYLE	STATUS AT FOLLOW-UP
#44 T.H.	(F)*	Able to stand & walk with braces; Dysarthria much less.	Quadriparetic Attending College.
#53 S.L.	(F)	Increased function in ambulating; less Ataxia.	
#54 B.S.	(F)	Increased motor function lower extremities; ambulates better.	Full Time Student.
#62 J.S.	(C)**	Marked increase in ambulation without side when stimulating system functions.	Ataxic, speech improved.
#66 T.T.	(C)	Increased ambulation & speech function.	Ambulates without aide.
#71 M.H.	(C)	Gait is improved; less Ataxia is demonstrable in upper extremities.	Ambulates without aide.

*Friedreich's Ataxia

**Hereditary Cerebellar Ataxia

CHART #3

IMPROVED PATIENTS WITH SPINAL CORD INJURY

PATIENT	SIGNIFICANT CHANGES IN LIFE-STYLE	FOLLOW-UP STATUS
#49 R.K.	Less deficit to pin prick & vibratory sensibility in lower extremities; no functional changes	Died pulmonary infection 16 mos. after implant.
#73 J.B.	Increase in motor function lower extremities, but spasticity did not change & no change in functional status.	Paraparetic; uses crutches.

CHART #4

IMPROVED PATIENT WITH TRANSVERSE MYELITIS

PATIENT	SIGNIFICANT CHANGES IN LIFE-STYLE	FOLLOW-UP STATUS
#55 G.M.	No pain in lower extremities; no spasticity, walks with feet flat on floor & not on toes; reports better control of urine.	Uses crutches.

CHART #5

LIST OF PATIENTS WITH NEUROGENIC BLADDER WHO IMPROVED

		Type of Bladder	Residual Urine Before	Residual Urine During	Urinary Frequency Per 24 hours Before	Urinary Frequency Per 24 hours During	Urine Incontinence Per 24 hours Before	Urine Incontinence Per 24 hours During	Time Followed
#1.	V.H.	Hypotonic	400 cc.	5 cc.	3-4	1-2	1-2	Continent	34 months
#2	L.K.	Hypotonic	120 cc.	60 cc.	8-10 Noct. 2	5 Noct. 0	1-3	Continent	34 months
#3.	M.M.	Hypotonic	10 cc.	0 cc.	10-12	4	Incont. Pad	Continent	33 months
#13	B.O.	Hypotonic	60 cc.	60 cc.	6-8 Drib.	6-8 No Drib.	0	0	31 months
#20.	H.T.	Hypotonic	100 cc.	40 cc.	6	3	0	0	Not implanted
#25	M.W.	Hypertonic	150 cc.	200 cc.	6-7 Noct. 3	3-4 Noct. 0	1-3	Continent	29 months
		Entire CNS function declined with infection.							
#29.	S.H.	Hypertonic	200 cc.	50 cc.	8-10	4	Incont. Pad	Continent	28 months
#32.	P.M.	Hypertonic	90 cc.	25 cc.	7	3	0	0	Not implanted
#39	R.B.	Hypertonic	125 cc.	75 cc.	10	3	3	1-2	30 months
#47.	V.C.	Hypotonic	60 cc.	10 cc.	6 Noct. 3	4 Noct. 0	3-4	Continent	15 months
#75.	R.S.	Hypertonic	200 cc.	50 cc.	10-12	4	4-5	Continent	6 months