SELECTIVE BLOCK TECHNIQUES OF URETHRAL SPHINCTER CONTRACTIONS IN SACRAL ANTERIOR ROOT STIMULATION

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***Abstract* - Conventional sacral anterior root stimulation (SARS) results in simultaneous activation of both, the detrusor muscle and the external urethral sphincter. We evaluated the possibilities of different neurostimulation techniques to overcome the stimulation induced detrusor-sphincter-dyssynergia and to achieve a physiological voiding.**

The literature was reviewed on different techniques of sacral anterior root stimulation to achieve selective stimulation of the bladder.

The current sacral neurostimulation of the bladder including the principle of poststimulus voiding would be improved, if selective detrusor activation could be obtained. This is possible with the application of selective neurostimulation in techniques of anodal block, high frequency block, depolarizing prepulses and cold block. Anodal block technique and cryotechnique are excellent methods for selective bladder activation and thus improve of stimulation induced voiding pattern.

***Index terms* - sacral nerve roots, selective neurostimulation, posterior rhizotomy, spinal cord injury, bladder control**

I. INTRODUCTION

Patients suffering from spinal cord injury above the second sacral spinal cord segment develop a spastic neuropathic bladder after the initial stage of spinal shock. The consequence is hyperreflexia of both bladder and urethral sphincter resulting in uninhibited contractions of the detrusor and spasticity of the pelvic floor musculature. Nowadays, restoration of bladder function is accomplished by performing complete sacral deafferentation together with the implantation of a neurostimulation system (e.g. Brindley bladder pacemaker) for sacral anterior root stimulation (SARS) [1-3]. However, one of the major drawbacks of this system is simultaneous contraction of bladder and urethral sphincter during stimulation, as the stimulated nerve roots contain both small unmyelinated fibers innervating the detrusor and large myelinated fibers innervating the urethral sphincter. Different neurostimulation techniques were developed to overcome the stimulation induced detrusor-sphincter-dyssynergia and to achieve a physiological voiding.

II. MATERIAL AND METHODS

The literature was reviewed on different techniques of sacral anterior root stimulation to achieve selective stimulation of the bladder in humans and animal models.

III. RESULTS

Previous experimental studies were performed to optimize stimulation technique and achieve selective activation of the bladder. Some stimulation techniques allow activation of small nonmylinated fibers without coactivation of large myelinated fibers.

In former animal studies almost selective stimulation of the bladder without or with little accompanying activation of the urethral sphincter was achieved using anodal block technique. This technique has been described by several authors. It takes advantage of the fact that close to an anodal contact the propagation of an action potential can be blocked due to hyperpolarization of the nerve membrane. If the membrane is sufficiently hyperpolarized, action potentials cannot pass the hyperpolarized zone and are annihilated. As large fibers need a smaller stimulus for their blocking than small fibers, a selective block of the large fibers is possible [4-6]. Thus selective activation of small fibers can be obtained by a combination of exciting both large and small fibers and by blocking, distal to the excitation point, the propagation of the

induced action potentials in the large fibers. Anodal block was achieved by application of monophasic rectangular pulses [7] or quasitrapezoidal stimulation pattern [5,8-10]. Acute animal studies showed, that anodal blocking could reduce the stimulus-induced intraurethral pressure increase by more than 80% [10,11]. It has been shown, that the anodal block technique can also be used in humans [12].

Alternatively selective activation of small nerve fibers is possible using selective high-frequency block. This technique is described with the use of two electrodes (one for blocking an one for stimulation) [13] or a single tripolar electrode (driven by two different stimulators to create a pulse train with small- and high-amplitude pulses) [14,15] in peripheral nerves. Results of this technique in sacral anterior roots stimulation showed the feasibility of a normal detrusor contraction with little activation of the external urethral sphincter in acute canine experiments [16].

Selective stimulation of small nerve fibers can also be obtained using depolarizing prepulses. The nerve fiber membrane can be made less excitable by preceding the stimulus pulse with a subthreshold depolarizing prepulse [17]. The prepulse elicits a larger depolarization in large fibers than in small ones. Thus the large myelinated fibers become less excitable than the small nonmyelinated fibers. The electrical stimulus following the prepulse activates predominately the small fibers [18]. Computer stimulations indicated that by the use of stepped prepulses selective activation of small nerve fibers is possible.

Sacral anterior root stimulation with sinusoidal pulses (8-20Hz) is possible for selective bladder activation in a canine model [19,20]. Sinusoidal stimualtion allows selective activation of a certain range of fiber diameters because it contains only a single frequency. Using a defined frequency range stimulation results in a detrusor contraction without simultaneous contraction of the external urethral sphincter.

Cryotechnique was developed for selective block of nerve fibers [21-23]. The neurophysiological blocking effect of cold on the nervous sytem is well known. The velocity at which impulses were conducted in individual axons through the cooled length of nerve slowed progressively as the temperature declined. Critical minimum conduction velocities were reached at higher temperatures in large meylinated axons rather than in small nonmyelinated ones. Peripheral myelinated fibers block at mean +7.3°C. The average of blocked nonmyelinated nerve fibers is found at +2.7°C [24,25]. The urodynamic effects of cryotechnology on sacral anterior root stimulation of the urinary bladder and the urethral sphincter were investigated in male foxhounds. Conventional neurostimulation was performed using a modified Brindley electrode. Simultaneously, the accompanying spinal nerves were cooled down in steps using a patented cryothermode. Subsequently, unilateral sacral anterior root stimulation was carried out while the ipsilateral pudendal nerves were cooled down in the same way. Cooling ranged from +25°C to a temperature initiating urethral sphincter block. During cooling of the spinal nerves, a complete cold block of the urethral sphincter was recognized in all animals. While the sphincter was completely blocked, the bladder was still activated [21-23]. Performing unilateral sacral anterior root stimulation and simultaneous cooling of the ipsilateral pudendal nerve, the urethral sphincter was completely blocked in 78%. The intravesical pressure remained unchanged before and during cold block [23]. The cryoblock was completely reversible within seconds to minutes in both series.

IV. CONCLUSIONS

Sacral anterior root stimulation would be improved, if selective bladder activation without simultaneous contraction of the external urethral sphincter could be obtained. This is possible by application of different selective stimulation techniques. Anodal block technique has shown to be feasible in animals and humans and to improve stimulation induced voiding. Alternatively, the cryotechnique is a new excellent method for selective block of nerve fibers. During conventional sacral anterior root stimulation of the bladder a complete and reversible block of

the urethral sphincter can be achieved while bladder activity is preserved.

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