The “sacral LION procedure” for recovery of bladder/rectum/sexual functions in paraplegic patients after explantation of a previous Finetech-Brindley-Controller

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Introduction

Spinal cord injury (SCI), in a moment, dramatically changes the life of the affected person. The loss of locomotion together with the impairment of urinary bladder and bowel function causes a profound deterioration in the quality of life. While “non plegic subjects” give their highest priority to the recovery of locomotion, patients affected from SCI consider, on the contrary, the disturbances in autonomic nervous system function to be even more devastating than the loss of motor and sensory function: Paraplegic subjects give normal sexual function as the highest priority and, when the first and second choice was combined, recovery of normal bladder function and bowel function were given the highest priority (1). The recovery of a normal bladder not only improves the quality of life of paralyzed patients but is also crucial for their health: Detrusor hyperreflexia that occurs as a consequence of spinal cord injury may cause incontinence and when it occurs with detrusor sphincter dyssynergia (DSD), high bladder pressures and vesico-ureteric reflux leads to renal impairment and finally failure which was, before the introduction of modern treatments, a common cause of death following spinal cord injury. Thus preventing upper renal tract damage is the primary aim of bladder management in patients with SCI. As a complete biological cure for spinal cord injury is unlikely to be developed in the near future (2), medical treatment and devices, specifically catheters, still play an important role in the daily regime of bladder management for most people with SCI. The high incidence of complications associated with the use of catheters but also the cost and undesirable side effects of medical treatments (botulinum, anticholinergic, antibiotics...), continue to motivate research into devices that could harness the nervous system to provide greater control over lower urinary tract function. Many devices which attempt to restore control of the lower urinary tract with electrical stimulation have been developed; The Finetech-Brindley sacral anterior root stimulator which is implanted by dorsal approach (laminectomy) has proven to be the only commercially successful electrical stimulation device to restore voiding in SCI-people (3). However in patients who
such a dorsal implantation is unfeasible as in patients after a dorsal fixation/osteosynthesis of the lombosacral rachis, or some patients with a spina bifida or after explantation of a previous Finetech-Brindley device, no any options does exist. In this special situation, a further promising (r)evolution comes from a completely different field of medicine, the “neuro-pelveology”. This new speciality deals with the pathologies of the pelvic nerves: Since we have demonstrated that laparoscopy is the only surgical approach which permits an easy and reproducible exposure of all pelvic motoric and autonomous nerves and plexi (4), neurosurgical procedures to the pelvic nerves have become feasible this way (5). Therefore we developed the laparoscopic transperitoneal technique of implantation of neural electrodes to pelveo-abdominal nerves which we have called “LION procedure” (Laparoscopic Implantation Of Neuroprothesis) and found different new applications in the treatment of refractory pelveo-abdominal neuralgia (6,7) and in some neurogenic bladder dysfunctions (8,9). We report here about a further application of the LION procedure to the sacral nerve roots for recovery of bladder and rectal function in spinal cord-injured paralyzed patients.

Material and Methods

We report here about our first series of height consecutive thoracic complete paralyzed patients who were send us for a sacral LION procedure – Laparoscopic Implantation Of Neuroprothesis to the sacral nerve roots – for recovery bladder and intestinal function after explantation of a dorsal implanted Brindley-Finetech controller with a sacral deafferentation. The reasons for the previous explantation were unrepparrable failure and/or infection of the cable or the controller device.

All procedures were performed by classical transperitoneal laparoscopic approach under general anesthesia, avoiding myorelaxants during the phase of intraoperative stimulation of the sacral nerve roots. Intravenous antibiotic treatment is systematically started the day before the surgical procedure for a period of two days. No any bowel preparation was done. During the procedure a microtip rectal probe and a 8F dual sensor microtip transurethral catheter with a filling channel are used for intraoperative urodynamic testing, while all other skeletal muscle responses are visually observed. For the intraoperative stimulation of the exposed nerves - the s.c. LANN-technique - we use a 5mm bipolar laparoscopic forceps producing a current with a square-wave pulse duration of 250 μs, a pulse frequency of 35 Hz, and a electric potential variable from 1 to 12 Volts (10). For the laparoscopy, one 10mm trocar is placed in the umbilicus to introduce a 10mm/0° optic and three further 5mm ports are placed in the lower abdomen, one on the middle line and two lateral beyond the epigastric arteries to introduce an atraumatic forceps, scissors and bipolar forceps to control the hemostasis. Since the operator is placed on the left side of the patient, the procedure begins with the incision of the left pararectal peritoneum medial of the left ureter followed by the
expansion of the pararectal space by absolute blunt dissection downwards to the level of the coccygeal bone. After exposure of the left sympathetic trunk and wide incision of the sacral hypogastric fascia, the left sacral nerve roots S1 to S4/5 are selectively exposed (figure 1). Exposure of the right sacral nerve roots is obtained coming from the left side by passing dorsally to the rectum - dorsally to the Waldeyer fascia - avoiding this way the entire dissection of the right pararectal space. Before implantation of the electrodes, the integrity and the good “stimulability” of the sacral nerve roots is controlled using the LANN-technique (11): The S4 roots provide motor innervation to the anal sphincter and often the pelvic floor, but not to limb muscles; The S3 roots innervate the pelvic floor and anal sphincter, and usually to the flexors, but rarely the triceps surae or gluteus maximus and never the biceps femoris or gluteus medius. The S2 roots always innervate the triceps surae, and usually the glutei, biceps femoris and pelvic floor. A rise in bladder pressure up to 60 cm H2O in women and 80 cm H2O in men must be obtained by stimulating S3, usually S4, and often S2 in order to make the decision for implantation of the electrodes (10V, 30Hz). The S5 roots, if present, usually gives little or no bladder pressure on stimulation and can therefore be ignored. Two standard Finetech-Brindley extradural electrodes (Neurocontrol, Cleveland, USA) are introduced into the abdominal cavity through the 10 mm umbilical trocar and placed bilaterally on the mixed S2 roots (channel B) and bilaterally on the mixed S3 and S4 roots (channel A) (figure 2). To avoid dislocation of the electrodes, the cables are sutured to the sacral periost on the midline with a non resorbable suture while the electrodes are fixed to the sacral nerve roots using their silicon rubber. Both electrodes cables are tunnelled on the left side between the internal iliac artery and the pelvic wall avoiding any contact with the ureter and the obturatoric nerve. The cables are finally connected to the receiver block placed subcutaneously in the lower left abdomen (figure 3).

The stimulation of the bladder and of the rectum is begun on the second or third postoperative day on channel A with the parameters 33Hz pulse width 415μs, mark 5.5s and space 19.4s: The electrically induced micturition is considered successful when a spontaneous micturition is obtained immediately with residual volumes being less than 30ml. Channel B is used for the stimulation of the gluteal muscle as a prophylaxes to decubitus and for a electrically-induced erection in males (19Hz/505μs).

Results

We have reported previously about the first patient of this series, a 50-year old woman, completely paralyzed at Th8 following an accident with SCI in October 1972 (12). Since then we have performed the same sacral LION procedure in seven further complete Th-paralyzed patients. The mean age of our patients was 42 years (range to 29-58 years) and the average body mass index was 27 (24-32). Median operative time for the entire procedure was 158 minutes ± 20 minutes and blood loss never exceeded 50ml; no intra- or postoperative
complications occurred. All patients went home on the 3rd/5th postoperative day in good physical form and in a positive frame of mind. No infection occurred and all the wounds healed well in all patients. Urodynamic testing was then carried out.

In one Th9 paralyzed women (SCI secondary to a shoot destruction of the spinal cord and spleen destruction → medial laparotomy with spleenectomy and total colectomy with a permanent paraumbilical ileostomy vor 12 years) after removal the previous Brindley controller because of an infection secondary to a surgical revision for cable failure, the intraoperative stimulation of the sacral nerves roots did not show neither any contraction in the lower extremities nor any changes in intravesical and intrarectal pressures; The implantation of new electrodes was cancelled since the sacral nerves roots were obviously completely damaged by the explantation of the Brindley controller.

In a 32 year old man, bifocal Th11 and Th4 complete paralyzed, intraoperative exposure and stimulation of the sacral nerves roots shows also full destruction of the sacral nerve roots S2, S3 and S4 on both side so that no implantation of this sacral roots was done. Stimulation of the left S1 shows in contrary a motion of the lower extremities; Because of a therapy-refractare autonomic dysreflexia and a spasticity of the left leg, we decide intraoperatively to implant a quadripolare electrode to the left lumbosacral trunk (LST) + S1 and a second quadripolar electrode to the superior hypogastric plexus (SHP). Postoperative neuromodulation of the LST+S1 permit full control of the spasticity while the neuromodulation of the SHP offer a complete control to the autonomic dysreflexia.

In all further patients (n=6), bilateral stimulation of S2 resulted in equal contractions of the gluteal muscles and erection in men (n=2); Bilateral stimulation of S3/S4 resulted in an immediate detrusor contraction up to 60 cm H2O in women (n=4) and 80 cm H2O in men (n=2) with a clinical micturition and an intrarectal pressure of 20 cmH2O with a defecation. With an actual follow-up ranging from 3 to 27 months, all devices are working optimally allowing full emptying of the bladder.

Discussion

The Finetech-Brindley bladder controller is presently considered as the only clinically available implantable system for bladder control. Bladder activation is obtained by stimulation of the ventral sacral nerve roots while dorsal rhizotomy permits elimination of detrusor hyperreflexia and DSD. However, even when the risks of the procedure are reported to be low in literature (13), the requirement of a laminectomy and the implantation of the electrodes to the spinal nerves exposed the patients to severe complications such as meningitis, encephalitis or liquor leakage with potential dramatic consequences for the health of the patient (14). As the receiver block must be
ventrally placed for the patient to have good access, the cables of the electrodes have to run beneath the skin from the back to the abdomen which exposes them to the risk of breakage; secondary procedures to repair implants or cable failures also exposes the patients to infection and/or the need to remove the entire device. On the contrary, because the laparoscopic approach permit to avoid the rhizotomy and the laminectomy, the LION procedure do not present any risk neither for meningitis, encephalitis, liquor leakage nor for destabilisation of the lower rachis (no risk of pathological fracture); The hospital stay is consequently significant lower, 3 postoperative days in average in our patients comparing with about three weeks or more in patients after dorsal approach. There are also less (or no) risks for cable breakage and infections (especially when the patients presents dorsal decubiti) or electrode dislocation as no cables run superficially under the skin and the electrodes are placed deep in the pelvis where no trauma or movements does occur. Concerning the surgical approach for the implantation of the electrodes to the endopelvic portion of the sacral nerves roots, the laparoscopic transperitoneal approach is the only minimal invasive way which permit microneurosurgical procedures - not only implantation of electrodes but also neurosurgical techniques such as decompression, intrafascicular neurolysis or anastomosis - to all pelvic nerves even those placed very deep into the pelvis behind the rectum. The endoscopic way obliges also the surgeon to a better knowledge about the pelvic retroperitoneal anatomy which is mandatory for a gentle dissection of the nerves in anatomic planes. In the special situation of the sacral LION procedure, the laparoscopic approach is a safe and easy way for implantation electrodes to the sacral nerve roots since it required just the dissection of the pararectal space while the anatomical plane lateral to the sacral hypogastric fascia is quite avascular and fat free even in adipose patients.

In the special situation of our paralyzed patients reported in this series, the sacral LION procedure was not a alternative but the only and last option for recovery a electrical-induced micturition and defecation: In situations where the explantation of a intradural implanted Finetech-Brindley after a intrathecal technique of implantation becomes necessary due to irreparable technical failures or infections, a new stimulator can be implanted extradurally. In the case of a primary extradural implantation as in the Barcelona technique (15) or a combined extradural + intrathecal procedure, spinal reimplantation of new electrodes can present a higher risk of irreparable damage to the nerves or can be impossible to perform due to postoperative fibrosis (arachnoiditis). The same problems exist in patients following dorsal sacral fixation of the rachis or in patients with spina bifida. In all these situations, the laparoscopic transperitoneal approach to the endopelvic sacral nerve roots is not an alternative but the only way to reimplant a new stimulator. This procedure is safe, reproducible even after several abdominal surgeries and for a surgeon trained in laparoscopic pelvic retroperitoneal surgery quite easy to perform.

Since no single device can be said to have solved the problem of bladder control as low-pressure physiological voiding cannot be produced yet and no device has successfully incorporated methods to produce both
voiding and suppression of neurogenic detrusor overactivity without severing any nerves (16), the laparoscopic approach to the pelvic nerves could be of major interest in the future for the management of paralyzed patients: Laparoscopy not only offer a surgical approach very distally to the pelvic nerves but also permit a optimal and reproducible approach to all pelveo-abdominal nerves even those involved in the locomotion...

References

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