The “LANN” technique for exposure of pelvic nerves in women - experience in 1218 cases

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Introduction

The pelvic splanchnic nerves were first described as nervi erigentes by Eckhardt in 1863 (1). Since this time, the neuroanatomy of the pelvic plexus using cadaveric microdissection and serial histologic sectioning in human fetuses or using the immunohistochemistry technique has been well explored. With the introduction of laparoscopy into the field of pelvic retroperitoneal surgery, laparoscopic exposure and dissection to all pelvic somatic and autonomous nerves has become possible and intraoperative elaboration of a functional cartography of the inferior hypogastric plexus using the LAparoscopic Neuro-Navigation - LANN-technique was established (2). In the actual work we report on our anatomical findings concerning the laparoscopic exposure, preservation (nerve-sparing), decompression and electrostimulation of the sacral nerves roots, especially S2-4 in their endopelvic portion, and of the pelvic splanchnic nerves during laparoscopic pelvic surgery.

Materials and Methods

Since 2000, we have paid particular attention to sparing the pelvic splanchnic nerves during transection of the cardinal ligament in all consecutive patients who underwent laparoscopic radical pelvic surgery for cervical cancer or for deeply infiltrating endometriosis of the rectovaginal space, employing the “LANN-technique” (3) to reduce the postoperative functional morbidity in laparoscopic radical pelvic surgery. All these patients were included in the study, as well as all the patients who underwent laparoscopic neurosurgical procedures on the sacral plexus for nerves decompression/neurolysis or for laparoscopic implantation of neuroprothesis (“LION”) procedures on sacral pelvic nerves for neuromodulation or functional electrical stimulation.

There were no exclusion factors, so that all consecutive patients who underwent the above cited kinds of procedures were included. For exposure of the sacral nerve roots S1 to S4, the dissection is started by the
development of the pararectal space medially to the ureter downwards to the level of the coccygeal bone by following the sacral bone on the middle line, at the retromuscular space. The sympathetic trunks are easily identified directly at the sacral bone medially to the sacral foramina. Identification of the sacral nerves roots require the transection of the sacral hypogastric fascia in it medial part between the sacral bone and the internal iliac vessels (figure 1). The sacral nerves roots can be completely exposed and separated from their emergence out of the sacral foramina to their fusion into the sciatic nerve, if required. The exposure of the pelvic splanchnic nerves is obtained by following the sacral nerve roots ventrally and recognized as a patchwork of small nerves sprouting out the mentioned roots (figure 2). Neurostimulation of the splanchnic pelvic nerves is done with the same bipolar forceps and the same current as in stimulation of the sacral roots.

In difficulties for identification the roots or when functional integrity of the nerves is uncertain or must be checked before implantation of electrodes, we have introduced a simple technique well-known in neurosurgery, the technique of intraoperative electrical stimulation of nerves with currents that are absolutely harmless for the nerves but strong enough to produce motoric reactions (250 µs / 35 Hz / 0 to 12 V) (4). Identification of the different sacral nerve roots can be easily obtained by simple observation of motoric reactions in the lower extremities and in the anogenital areas: while S4 stimulation does not produce any motoric reaction in the lower extremities, stimulation of S3 nerves is confirmed visually by a deepening and flattening of the buttoc groove as well as a plantar flexion of the large toe and to a lesser extent of the smaller toes. Stimulation of S2 produces an outward rotation of the leg and plantar flexion of the foot as well as a clamp-like squeeze of the anal sphincter from anterior/posterior (5).

During laparoscopic procedures with implantation of electrodes to the pelvic nerves (figure 3) for control or restoration of lost pelvic functions secondary to pelvic nerves damages or to spinal cord injuries (apar- and tetraplegie) or other pathologies from the CNS (cauda equina syndrome, spina bifida, Parkinson syndrome, Multiple sclerosis…), intraoperative rectomanometry and urodynamic testing are mandatory for control impact of stimulation on pelvic organs functions.

For an optimal effect of intraoperative stimulation, interruption of any myorelaxation before starting with the stimulation is absolutely mandatory.

All the trials were performed in accordance with the 1975 Declaration of Helsinki and approval was gained for the LANN technique from the medical ethics committee at the University of Jena (0390-12/99).

Results

The study was performed in 1218 consecutive patients who underwent surgical procedures reported in table 1; all procedures were performed by the author (MP) in different institutions.
Laparoscopic exposure of the sacral nerves roots S1-4 and corresponding pelvic splanchnic nerves was obtained in all patients, without any intraoperative major complications or necessity of conversion to laparotomy. Body mass index and previous gynecological interventions did not make any difference in feasibility of the dissection; from the moment of opening the pararectal space to full exposure of the sacral nerves roots, dissection required only few minutes per side. In 19 patients with previous history of deep anterior colorectal resection/anastomosis, because of strong fibrosis of the pararectal space and potential risk for rectum lesion, we modified the procedure and exposed the sacral nerves roots by passing laterally to the internal iliac artery. This way is feasible too, but expose the patient to higher risk of vascular injury, while the “pararectal way” offer exposure of the nerves in an anatomical space, quite free of vessels.

In nerve-sparing pelvic procedures, only the roots S2, S3 and S4 were identified – since these contain all vesical and rectal parasympathetic nerves and all pudendal fibers.

Exposure of the sacral nerve roots in men was felt to be more difficult than in women due to the narrower male pelvis and the greater muscle mass of the piriformis, which frequently grows around the nerve roots.

Anatomical findings

While the S1 is exposed at the level of the internal and external iliac artery bifurcation, the sacral nerve roots S2-4 expand from the level of the ovarian fossa downwards to the level of the sacro-uterine ligaments. Therefore and because of such close anatomical relationship, retroperitoneal interventions at the level of the ovarian fossae and procedures to the sacrouterine ligaments potentially expose patients to lesions to the sacral nerve roots S2 and S3.

S2, S3 and S4 are very close, with decreasing diameters, about half centimeter for S2, about 3 mm for S3 and about 1-2 mm for S4. Tangential connection fibers between theses roots are frequently observed. By using maximal magnification possible offered by the HDTV camera, S2 and S3 are constituted by several parallel-fibred bundles that differ by color: some of them are ivory-white in color, other yellowish/pink. S4 is usually constituted by only two fascicules, one ivory-white and one yellowish/pink (figure 4).

Laparoscopic dissection of the pelvic splanchnic nerves shows an anatomical particularity: the pelvic splanchnic nerves emerge from the sacral nerve roots S3 and S4 in woman, also from S2 in man, and are building first a meshwork of 5 to 10 fibers from about 0,5 mm in diameter laterally to the sacral hypogastric fascia. The further distal dissection of these fibers shows two different groups of nerves: one group of nerve fibers – we called “rectal nerves” - are taking an medial oblique direction, are crossing this way the sacral hypogastric fascia and then the pararectal space before they anastomose to the inferior hypogastric plexus at the latero-dorsal aspect of the
rectum. The second group of nerve fibers – we called “vesical nerves” - are taking a more vertical direction parallel to the pelvic sidewall and first make anastomose with the inferior hypogastric plexus laterally and ventrally to the level of the rectum, about 2-3 cm below the level of the sacrouterine ligaments.

In patients with cervical cancer (Stages I, IIa), we never had observed any lymph node nor any tumor dissemination in the area of the pelvic splanchnic nerves, even in large IB2 tumors.

In deeply infiltrating infracardinal endometriosis of the parametria, the most frequent involved roots were S2 and S3. While dissection of the roots is technically feasible, dissection of the pelvic splanchnic nerves out of an endometriotic nodule is technically impossible, at last because of small size of the nerves.

In 57 patients with sacral radiculopathy unknown etiology, exploration of the sacral nerve roots permit exposure of atypical enlarged veins compressing the roots. Resection of these veins to treat pain is then the treatment of choice as shows in previous work (6). Risk factors for such deep sacral veins are in our series parametric endometriosis - obviously because of induced neoangiogenesis - (n=39), pelvic congestion syndrome (n=3) and antecedent of hysterectomy because of increase pelvic sidewall blood flow (n=41).

Such a sacral varicose has been also observed in patients with bladder overactivity and/or hypersensitivity unknown genesis in 39 patients of the series.

Neuro-physiological findings

Selective stimulation (250 µs / 35 Hz / 3 V) of all three sacral nerves roots S2, S3 and S4 induces a pressure rise of anal and urethral sphincters in urodynamic; anal sphincter contraction is also easy perceptible by simple rectal digital palpation. Stimulation of S2 induces stronger sphincter contraction than S3 and S4 when same currents are used. Stimulation of S2 does practically never induce any change in rectal and detrusor pressure, while stimulation of S3 and S4 induce such rise of both vesical and rectal pressure. Selective stimulation of the ivory-white fascicules induces motoric answers corresponding to the stimulated root (= efferent fascicules), while stimulation of the yellowish/pink fascicules do not induce any reaction (= afferents fascicules).

Selective stimulation (250 µs / 35 Hz / 3 V) of some of the “rectal fibers” resulted in an isolated rise in rectal pressure, while selective stimulation of some of the “vesical nerves” induces an isolated rise in intravesical pressure. This demonstrates that pelvic splanchnic nerves are composed by efferent and afferent fibers, and that the parasympathetic nerves (efferent fibers) of the rectum and of the detrusor are different nerves that are taking different ways respectively to the rectum and to the bladder.
Rise in pressure is proportional to the current applied to the nerves and varies between 10 and 40 cmH\textsubscript{2}O for the bladder and 10 to 20 cmH\textsubscript{2}O for the rectum. High voltage stimulation (> 4-5V) induces after few minutes a loss of motoric reactions, obviously due to fatigue of the organs or of the nerves themselves.

Discussion

Laparoscopic exposure of all somatic and autonomic pelvic nerves became feasible not due to new findings in the pelvic neuroanatomy, but due to the introduction of laparoscopic surgery into the field of retroperitoneal pelvic surgery: laparoscopic magnification provides the surgeon a microscopic vision of such small nerves even in the depth of the pelvis or in areas difficult to access by laparotomy. The second important aspect making this dissection feasible is the fact that laparoscopy in the retroperitoneal space demands from the surgeon a better knowledge concerning pelvic anatomy, and obliges him also to undertake gentle and respectful dissection of all structures using the correct anatomical planes. Development of video endoscopy and microsurgical instruments enables not only a unique access to pelvic nerves, but also permit neurosurgical procedures to these nerves with optimal visibility, magnification of the structures and appropriate instruments (7-9). The technique of intraoperative stimulation is then very helpful when anatomical difficulties or doubts about the functional integrity of the nerves occur but also enable the surgeon to establish an exact functional cartography of the pelvic somatic nerves. This in turn make possible surgical neuro-functional approaches, such as LION procedures to the pelvic nerves for controlling axonal pelvic pain (10) and dysfunctions (11) or for recovery lost functions in iatrogenic pelvic nerve damages or in spinal cord injuries and pathologies (spina bifida, multiple sclerosis) (12).

An important finding with clinical consequences of our study is the feasibility of exposure and sparing of the pelvic splanchnic nerves during radical pelvic procedures. From oncological aspect, resection of the pelvic splanchnic nerves is not necessary for an optimal radicality and do not ameliorate oncological prognosis of patients with cervical carcinoma. However postoperative bladder dysfunctions after radical hysterectomy are still a well known and frequent morbidity (13). However identification and preservation of the nerves during resection of the parametric tissues is enough to reduce significantly risks for postoperative rectum and bladder hypo- or atonia (14).

In patients with deeply infiltrating endometriosis, our technique of nerve sparing is not based on the dissection and sparing the nerves out of an endometriotic nodule – that is technically not feasible -, but is based on the primary dissection and preservation of contralateral nerves where endometrioses do not involve the parametria. Problematic are bilateral parametrial infiltrations since bilateral resection expose patients for rectum and bladder hypo- or even atonia. In such situation preoperative explanation of risks to the patients is essential and we prefer
personally - in agreement with the patient - to leave part of the disease on one side inside to avoid this way bilateral nerve damages.

The discovery of enlarged veins responsible for an irritation or compression of the sacral nerve roots as potential etiologies for sacral radiculopathies and eventually for bladder hypersensitivity or hyperactivity, enable a completely new etiopathogenic understanding of these pathologies. In this view, an “interstitial cystitis” should be not a pathology *per se* of the bladder itself, but could be a symptom of another pathology, such as a pathology of the pelvic nerves.

**Conclusions**

Laparoscopy offers optimal surgical conditions for exposure and exploration of all pelvic autonomic and somatic nerves. This enables not only to reduce functional morbidity secondary to radical interventions in gynecology, but also to treat nerve pathologies and damages using neurosurgical techniques through laparoscopic way. All these new aspects are the results of a pioneering work which has been resumed under the term “neuropelveology”. This new specialty in medicine focuses on the prevention, diagnosis and treatments of pathologies of the pelvic nerves and plexuses that offer new therapeutic options for an enormous number of patients.

**References**


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*DIE: deeply infiltrating endometriosis - SCI: spinal cord injury - LION: laparoscopic implantation of neuroprothesis*
Figure 1: Identification of the sacral nerves roots S1-5
Figure 2: Identification of the pelvic splanchnic nerves (PSN) medially to the sacral hypogastric fascia
Figure 3: Sacral nerves roots LION procedure – octipolar neurostimulator lead placed from S2 to S4
Figure 4: Laparoscopic exposure of S4 – Two bundles different in color are well identified – the ivory-white fascicule is efferent (myelin), the yellowish-pink is an afferent fascicule.