The laparoscopic exposure of the sacral roots and the pelvic splanchnic nerves in women during radical pelvic surgery – feasibility of the technique and new neuro-anatomic findings

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Introduction

The nervi splanchnici pelvini 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 somatetic and autonomous nerves has become possible (2) and intraoperative elaboration of an functional cartography of the inferior hypogastic plexus using the LAparoscopic Neuro-Navigation - LANN-technique (2) was established. In the actual work we report on our anatomical findings concerning the laparoscopic exposure and electrostimulation of the sacral nerves roots in their endopelvic portion and of the pelvic splanchnic nerves in women 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 deep infiltrating endometriosis of the rectovaginal space (3). The „LANN-technique“ to reduce the postoperative functional morbidity in laparoscopic radical pelvic surgery. All these patients were included in the study but also all our patients who underwent laparoscopic neurosurgical procedures on the sacral plexus for pelvic neurosurgical procedure or for laparoscopic implantation of neuroprothesis on sacral pelvic nerves for neuromodulation or functional electrical stimulation.
For the inclusion of the patients for this study, no any exclusion-factor like prior surgery of adipositas were taken into consideration so that all consecutive patients send to us where included. Before operation, all patients completed a standardized questionnaire including questions on bladder function, in particular on miction difficulties on the basis of the International Prostatic Symptom Score (4). Additional measures included sonographic residual urine volume measurement and assessment of the upper urinary tract.

For exposure of the sacral nerve roots S1 to S4, the dissection is started by dissection of the pararectal space medially to the ureter downwards to the level of the coccygeal bone by following the sacral bone on the medial line. The sympathetic trunks are easily identified directly at the sacral bone medially to the sacral foramina. Exposure of the sacral nerves roots is obtained first after transsection 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 it is required. 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) (Possover M et al. (2004) The „Laparoscopic Neuro-Navigation“ - LANN: from a functionnal cartography of the pelvic autonomous neurosystem to a new field of laparoscopic surgery. Min Invas Ther & Allied Technol 13: 362-367). The exposure of the pelvic splanchnic nerves is obtained by following the S3 and S4 roots ventrally and recognized as a patchwork of small nerves sprouting out the mentioned roots (figure 2). Neurostimulation of the splanchnic pelvic nerves to obtain differentiation between rectal and vesical fibers can be performed with the same bipolar forceps and the same current as in stimulation of the sacral roots.

In nerves sparing pelvic procedures, only the roots S2, S3 and S4 are of importance - because their contains all vesical and rectal parasympathetic nerves and all pudendal fibers; effect of stimulation can be simply observed 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 confirm visually by a deepening and flattening of the buttock 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

During laparoscopic procedures with implantation of electrodes to the pelvic nerves for control or restoration of loss pelvic functions secondary to pelvic nerves damages (figure 3), to spinal cord injuries or other pathologies from the CNS (cauda equine 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 more than 1218 consecutive patients who underwent surgical procedures reported in table 1, all procedures performed by MP in different institutions. Laparoscopic exposure of the sacral nerves roots and corresponding pelvic splanchnic nerves could be 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 S2-S4, 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 surgeon for potential vascular injury, while the “pararectal way” offer exposure of the nerves in an anatomical space quite free of vessels.

In our experience, exposure of the sacral nerve roots in man is more difficult than in woman since the male pelvis is narrower and the nerves deeply hided into the pyriform muscles as in woman.

By using maximal magnification possible offered by the HDTV camera, the different sacral roots are constituted by several parallel-fibred bundles that differ by color: some of them are absolutely ivory-white, other yellowish/pink. The white bundles (myelin!) are efferent fascicules which stimulation induces motoric answers
corresponding with the root that is stimulated, while the yellowish/pink fascicules contains afferents fibers and are therefore sensitive pathways.

Stimulation of all three sacral nerves roots S2, S3 and S4 induce a rise of anal and urethral sphincters, that confirm that pudendal fibers are passing through all three roots; stumlation of S2 do not induce any change in rectal and detrusor pressure, while stimulation of S3 and S4 induce such rise of vesical and rectal pressure.

Laparoscopic dissection of the pelvic splanchnic nerves shows na anatomical particularity unknown until now: the pelvic splanchnic nerves are building a meshwork at their emergence out of the sacral nerves roots, however further dissection ventrally shows that rectal and vesical fibers are taking different directions. The rectal fibers are taking an 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. Selective stimulation of this fibers with a current of 10V/30Hz/250µs show an isolated rise of rectal pressure between 10 and 20cm H20. In contrary the vesical fibers are emerging more distally out of the sacral nerve roots S3 and S4, are taking a more vertical direction parallel to the lateral pelvic wall and first make anastomose with the inferior hypogastric plexus laterally at the level ventrally to the level of the rectum, at the level of the bladder pillar. Selective stimulation of these fibers induces an isolated rise in intravesical pressure between 20 and 40cm H20 (=efferent vesical parasympathetic nerves).

**Discussion**

Laparoscopic exposure of all somatic and autonomous 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 allows the surgeon a microscopical vision of such very 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 oblige the surgeon in the retroperitoneal space to 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 (Possover M et al. (2007) Anatomy of the sacral roots and the pelvic splanchnic nerves in women using the LANN technique. *Surg Lap Endosc Percutan Tech* 17: 508-510), but also permit neurosurgical procedures to these nerves with optimal visibility, magnification of the structures and appropriate instruments (Possover M (2009). Laparoscopic management of endopelvic etiologies of pudendal pain in 134 consecutive patients. *J Urol* **181**: 1732-1736 - Possover M (2010) New surgical evolutions in management
of sacral radiculopathies. Surg Technol Int 19: 123-8 - Possover M (2009) Laparoscopic management of neural pelvic pain in women secondary to pelvic surgery. Fertil Steril 91: 2720-5). 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 somatetic nerves. This in turn make neuro-functional procedures such as LION procedures to the pelvic nerves - Laparoscopic Implantation Of Neuroportheisis – for control pelvic dysfunctions or for recovery loss functions in iatrogenic pelvic nerves damages or in spinal cord injuries and pathologies (spina bifida, multiple sclerosis) possible (Possover M, Schurch B, Henle KP (2010). New pelvic nerves stimulation strategy for recovery bladder functions and locomotion in complete paraplegics).

A further very important finding with clinical consequences of our study is the feasibility of exposure and therefore sparing of the pelvic splanchnic nerves while radical pelvic procedures. Even when resection of the pelvic splanchnic nerves is not necessary for an optimal radically and do not ameliorate oncological prognosis of patients with cervical carcinoma, postoperative bladder dysfunctions after radical hysterectomy is still a well know and frequent morbidity (Low JA, Mauger GM, Carmichael JA. The effect of Wertheim hysterectomy upon bladder and urethral function. Am J Obstet Gynecol 1981; 139: 826-834). We had showed previously that in radical hysterectomy, simple identification and preservation of the nerves while resection of the parametric tissues is enough to reduce significantly risks for postoperative dysfunctions (Possover M, Quakernack J, Chiantera V (2005). The „LANN-technique“ to reduce the postoperative functional morbidly in laparoscopic radical pelvic surgery. J Am Coll Surg 6:913-7).

In patients with deeply infiltrating endometriosis, our technique of nerves sparing is not based on the dissection and sparing the nerves while dissection of a endometriotic nodule, but is based on the dissection and preservation of contralateral nerves where endometrioses do not involved the parametria. Indeed, we strongly believe that dissection pelvic splanchnic nerves out of an endometriotic nodule is not feasible technically and full resection of a parametrial nodule requires the sacrifice of involved nerves. Therefore, when lesion is unilateral, no any dissection of the contralateral nerves is required. When a deep anterior rectum resection is done, we first expose the nerves on the side free of endometriosis and then dissected the involved side. Problematic are bilateral parametrial infiltrations since bilateral resection expose patients for detrusor 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 nerves damages.
Conclusions

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

<table>
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<tr>
<th>Indications</th>
<th>Number of procedures</th>
<th>Procedures</th>
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<tr>
<td>Cervical cancer</td>
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<tr>
<td>Rectum DIE</td>
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<td>Sacral/pudendal LION procedure</td>
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<tr>
<td>SCI – spina bifida cauda equina</td>
<td>n=28</td>
<td>Sacral/pudendal/femoral LION procedure implantation of a</td>
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DIE: deeply infiltrating endometriosis - SCI: spinal cord injury - LION: laparoscopic implantation of neuroprothesis

References


Figure 1: Identification of the sacral nerves roots

Figure 2: Identification of the pelvic splanchnic nerves
Figure 3: Sacral nerves roots LION procedure