The „Laparoscopic Neuro-Navigation“ - LANN: from a functionnal cartography of the pelvic autonomous neurosystem to a new field of laparoscopic surgery.

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Introduction

The nervi splanchnici pelvini were first described as nervi erigentes by Eckhardt in 1863 (Eckhardt C. Untersuchungen über die Erektion des Penis beim Hunde. Beitr. Anat. Physiol, 1863, 123:3). Since this time, the neuroanatomy of the pelvic plexus using cadaveric microdissection and serial histologic sectioning in human fetus or using the technique of the immunohistochemistry was well explored. However the most of us, gynecologist do not have this knowledge and this lack of information probably is the major factor contributing to the incidence of iatrogenic dysfunction of the bladder and of the rectum after pelvic operations. Our main work over the last 7 years was to improved the technical feasability of exposure and preservation of the pelvic nerves for reduction of the functionnal morbidity of our surgical procedures (Possover M, Stöber S, Plaul K, Schneider A. Identification and preservation of the motoric innervation of the bladder in radical hysterctomy type III or IV. Gyneco Onco 79, 2000, 154-157 - Possover M. Laparoscopic exposure and electrostimulation of the somatic and autonomous pelvic nerves: a new method for implantation of neuroprothesis in paralysed patients? In Press in Journal Gynecological Surgery – Endoscopy, Imaging, and Allied Techniques, 2004). However during the surgery, only exposure of the nerves do not give enough informations about their exacte function; thus the next step of our work was to improved the feasibility and reproductibility of an intraoperative assessment of the functionnality of the exposed nerves by using the laparoscopic electrostimulation.

Materials and Methods

For exploration of the functionnality of the exposed nerves, a electrostimulation using a laparoscopic bipolar forceps and a conventional stimulator 0-6 volts and 2,5Hz are used. For intraoperative urodynamik testing a microtip rectal probe and a 8F dual sensor microtip transurethral catheter with filling channel are used. The sensor at
the tip of the rectal probe is placed 7cm proximal to the anal sphincter while the transurethral catheter is inserted in such a manner that the urethral and the intravesical pressure could be measured concomittantly but separated. The bladder capacity during the neurostimulation is 150 to 200cc.


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Standardized intraoperative data collection included documentation of identification (operative time, complications) concerned following nerves and plexus:

The superior hypogastric plexus and the left sympathetic trunks (lumbar level)

In our technique of laparoscopic paraaortic lymphadenectomy, exposure and consequently preservation of the superior hypogastric plexus and of the lumbar sympathetic trunks is performed systematically (Possover M. Laparoscopic exposure and electrostimulation of the somatic and autonomous pelvic nerves: a new method for implantation of neuroprosthesis in paralysed patients? In Press in Journal Gynecological Surgery – Endoscopy, Imaging, and Allied Techniques, 2004; 1:87-90). In 30 consecutive patient who underwent this technique for cervical cancer, neurostimulation of the superior hypogastric plexus and of the left lumbar sympathetic trunk was done. In further 15 patients who underwent isolated laparoscopic preneural neuroectomy for endometriotic pelvic pain, minutious anmnese and gynecologic examination was done. Preoperative and three-months postoperativ results were compared in order to find any morbidity due to this technique.
The both sympathetic trunks at the coccygeal level

In all our patients with deep infiltrating endometriosis in who laparoscopic mobilisation of the rectosigmoide from the sacral bone was mandatory (n=231), exposure of the both coccygeal sympathetic trunks was done. At this level just bevor the anatomical fusion of the both sympathetic trunks at the top of the coccygeal bone, few little neural fibers which anastomoses ventrally to the inferior hypogastric plexus were founded. Using a normal injection needle, vertical puncture of the dorsal wall of the vagina was done in order to locate the level of the fusion of this anastomosis to the inferior hypogastric plexus. Neurostimulation was done too and when transection of this little anastomosis because of endometriotic infiltration was required, postoperative morbidity was exactly documented.

The inferior hypogastric plexus

The study of the pelvic plexus was done in patients who underwent a LAVRH type 3 for cervical cancer (n=167) and in patients who underwent laparoscopic radical surgery for endometriosis of the rectovaginal septum (n=482). Exposure of this plexus was done by dissection and expansion of the pararectal space laterally and medially to itself. Neurostimulation of its different levels was done in the same condition of rectal-vesical pressures-enregistrement. Exact localisation of the different neural fibers anastomosing in this plexus was documented. Parallely, the type and extension of the resection of the rectovaginal ligament was exactly documented and compared posteriorly with the postoperative morbidity.

The nervi splanchnici pelvini and the pudendal nerve

The dissection of the sacral plexus and the splanchic pelvic nerves was done in the same collective of patients than in the study of the inferior hypogastric plexus. The exposure of the splanchic pelvic nerves have to be done in the deepness of the pararectal space: the dissection is started by the incision of the pararectal peritoneum medial to the ureter and expansion of the anatomic pararectal space is carry on by absolut blunt dissection downwards to the level of the coccygeal bone. The dissection is expanded laterally to the hypogastric fascia which is transected in order to open the space lateral from him. The sacral roots S1 to S4 are selectively exposed by absolute gentile dissection and confirmation of the origin of the different sacral roots is gained by using laparoscopic electrostimulation: 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 anterior/posterior. Since in human the most part of the parasympathetic and pudendal nerves are originate from S2 and S3 (Brindley GS, Polkey CE, Rushton DN, Crdoso L. Sacral anterior root stimulators for bladder control in paraplegia: the first 50 cases. Journal of Neurology, Neurosurgery and Psychiatry 1986; 49: 1104-1114), gentle dissection of this both roots is extended ventrally by using optimally the magnification of the endoscope. All nerves sprouting out the both roots are exposed and dissected ventrally in order to founded and described their different anatomical patway into the pelvis. More distally, about 1 to 1,5cm before the sciatic nerv enter the sciatic foramen, the pudendal nerve is exposed on the caudal border of the sciatic nerve to ist enter through the canal of Alcock.

Selective neurostimulation of all this exposed neural structure was done. The operative time required for exposure of the sacral roots, the splanchnic nerves and the origin of the pudendal nerve starting up the incision of the peritoneum the pararectal gutter was measured.

Prior to discharge from the hospital, data on micturition difficulties were recorded for all patients, and the residual urine volume after micturition was measured sonographically.

After a median period of 6 months following the surgical procedure, a questionnaire used previously in patient after radical surgery for endometriosis was send our patients or was completed during consultation (Possover M, Mallmann P. Follow-up of patients after laparoscopic vaginal resection of the endometriosis of the rectovaginal septum with colorectal anastomosis. Journal of Pelvic Surgery (2002): 83-88).

All the trial was done in accordance with the 1975 Declaration of Helsinki. For the use of the laparoscopic neurostimulation, we obtained ethics approval from the medical ethics committee of our institution, and every patient provided written informed consent.

Results

The superior hypogastric plexus and the left sympathetic trunks (lumbar level)

Whether neurostimulation from the superior hypogastric plexus nor from the left sympathetic trunk produces any changes in intravesical, intraurethral or intrarectal pressures. Destruction of the superior hypogastric plexus shows in 82.3% of the patients an hypoesthesia of the cervix and in 62.7% a lost of wetness of the vagina specially during sexual activity. The mean operative time for exposure of the superior hypogastric plexus up the incision of the retroperitoneum was 7 minutes. No complication occurs for this dissection.
The both sympathetic trunks at the coccygeal level

The exposure of this nerves was feasible in all the patients without any complications since this dissection is done dorsally to the Waldeyer fascia, a quite avascular anatomic plane. This neural fibers anastomoses the inferior hypogastric plexus between cranially the fibers coming from the inferior hypogastric nerves and caudally the nervi splanchnici pelvini. Neurostimulation of the anastomoses to the inferior hypogastric plexus did not produces any change in intravesical, intrarectal or urethral pressures. In all situations where this anastomosis had to be resected on both sides (n=38), the patients reported postoperatively a completely loss of sensation of fullness for the bladder and for the rectum. At the 1-year-follow-up, all this patients had developped a new sense for fullness of the bladder and of the rectum, mostly as a intestinal discomfort or in few cases as a cutaneous flush or sensations of pain in the shoulder. No patient developped any kind of bladder atony or incontinence.

The inferior hypogastric plexus

Exposure of the pelvic plexus did not showed any surgical difficulties. Neurostimlation of the suprareteral portion of the inferior hypogastric plexus did not shows any change in intravesical, intrarectal or urethral pressures. Neurostimulation of the infraureteral portion of the inferior hypogastric plexus in the bladder pillar could not be done due to a limited surgical access. In all patient where a part of the inferior hypogastric plexus had to be resected, exact correlation between the localisation and extension of this desctruction with the postoperative morbidity was done:

- Destruction of the upper 2-3cm of the pelvic plexus produce a hypo-anesthesia of the fornix and the dorsal vaginal cuff. No loss of sensation of fullness of the bladder or of the rectum or any vesico-rectal dysfunction where founded.
- The destruction of the next 1-2cm produces the same morbidity associated with a lost of sensation of fullness for the bladder and occasionaly for the rectum without vesico-rectal dysfunction.
- The destruction of the pelvic plexus up 3cm caudally to the pouch of Douglas produce the same morbidity accompanied by a bladder atonie alone if this destruction was done ventrally to the level of the rectum, and a rectal atonie if this destruction was done lateraly to the rectum.

The pelvic splanchnic nerves and the pudendal nerves
For exposure of the sacral plexus, the splanchnic pelvic nerves and the pudendal nerve on one side, a mean of 26 minutes was required. Neither intraoperative complications nor postoperatively functionnal morbidity occured. However particular attention have to be paid to void injury of the pudendal vein.

Neurostimulation of the different sacral roots permits confirmation of the functionnality of them in all patients, so far the anethesia did no included any muscular relaxation.

By following the sacral root ventrally, first the splanchnic pelvic nerves are exposed: medialy to the sacral hypogastric fascia, there are building a metchwork of 5 to 7 little nerves which after sprouting out with different orientations (figure 1) building a lateral and a medial nerves-group; The more medial groupe of nerves are crossing the pararectal space tangientialy and anatomoses to the pelvic plexus at the postero-lateral aspect of the rectum while the more lateral fibers are more vertical and abord the inferior hypogastric plexus directly if the lateral aspect of the rectovaginal ligament. In the plexus himself or more ventrally in the bladder pillar no further dissection of this nerves was technically feasable. Using the transfixon of the vagina with a needle, we shows that this nerves crosses the lateral part of the vagina at the level between the upper and the medial third of the vagina.

In 25% of our patients, the parasympathetic nerves are not sprouding separed from each other, but are build to trunks from about 1-2mm in diameter, a medial and a lateral one. The medial trunk after transfixon of the sacral hypogastric fascia separates in a further trunk which is carry on cranially - the „sigmoidal“ branche - and on caudally - the „rectal“ branche – (figure 2). The more lateral trunk anastomose to the inferior hypogastric plexus directly in the bladder pillar.

Neurostimulation of the medial groupe of nerve shows:

- an increasing of the pressure in the rectum without any significant change of the intravesical pressure (figure 3). The description of the exact neurophysiologic parameters will be the topic of an further publication.
- by laparoscopic inspection of the pelvis, spastic contractions of the terminal rectum are seen while by inspection of the vulvo-anal region an isolated perianal muscular contraction with retraction of the perinal skin could be observed too.

The neurostimulatin of the second lateral nerves induce

- an increasing of the intravesical pressure without any significant change of the rectal pressure (figure 4).
- by the laparoscopic inspection, no contraction wether from the rectum nor from the bladder could be observed. By the macroscopic inspection of the vulvo-anal region, a isolated periurethral muscular contraction has to be seen.
Selective neurostimulation of the pudendal nerve shows a strong contraction of the external anal sphincter and an increasing of the intraurethral pressure to 80-90cmH₂O.

In 19% of our patients, we found two trunks sprouting out of the sacral root S3 from about 1-2mm in diameter, a medial and a lateral one. The medial trunk after transfixion of the sacral hypogastric fascia separates in a further trunk which is carry on cranially - the „sigmoidal“ branche - and on caudally - the „rectal“ branche – (figure 2). The more lateral trunk anastomose to the inferior hypogastric plexus directly in the bladder pillar. Stimulation of the medio-dorsal trunk shows an increasing of the intrarectal pressure as well as a contraction of the anal sphincter since the stimulation of the latero-dorsal trunk show an isolated vesical answer with contraction of the sphincter urethral.

Thus this trunks seems to include parasympathetic and somatic nerves.

Discussion

Due to the magnification effect and the possibility of a bloodfree dissection even in the deepness of the pelvis, laparoscopic surgery in the retroperitoneum is becoming one of the most useful and important instrument for learning the pelvic retroperitoneal anatomy. Laparoscopic surgery do not just incite the surgeon for learning the pelvic anatomy but oblige him to learn it: bleeding in retroperitoneal space by laparoscopy could be dramatic due to the loss of optimal vision and unpossibility of compression of the vessel. If the surgeon want to make the procedure as safe as possible, it is of great importance to avoid bleeding by knowing where the vessels have to be expected during the dissection. In the same matter, reduction of postoperative functional morbidity can only be reduce by preserving the nerves. If we want to preserve structure, we have to know that this structures exist and we have to know where we have to look for identified them. The combination of a good knowlege about the pelvic neuroanatomy and the technique of the laparoscopy with the magnification due to the endoscope allows us quite the same quality of dissection as on cadaver but we less time since the tissue are fresh and all the structures have their own aspect and color. However the topographic pelvic neuroanatomy shows much more variations than the vascular pelvic anatomy and exposure of the nerve could be done in the pararectal space, but dissection need time and removing of abondant surrounding fat tissue: the risk of cutting the nerves can occure bevor the surgeon was abble to recognise it. When nerve are disturbed by a to close electrocoagulation or by an inapropriate technique of dissection, because of a temporary neurapraxy of the exposed nerves, the neurostimulation will not bring any information. Thus we developped the exposure of the splanchnic nerves laterally to the sacral hypogastric fascia: exposure of the sacral plexus laterally to this fascia do not required a lot of time since the nerves are quite free without surrounding fett-tissue. Based on this technique, we have developped the new concept of laparoscopic neuro-navigation – the
LANN-technique - since the surgeon is able to win by himself during the procedure the information of the functionnality of all exposed nerves and to make in fact an individuell functionnal cartography of the pelvic autonomous neurosystem. Based of our founding by using this technique, we developpe a functional cartography of the inferior hypogastric plexis which is not a anarchic patchwork of sympathetic and parasympathetic neural fibers but present thre functional levels: The upper part is constitue by the sympathetic fibers coming from both inferior hypogastric nerves which are responsable for the wetness of the vagina and the feeling of pain/pleasure to the cervix and the vagina. Transection of this fibers make an hypo-anesthesia of this region, which is the expected effect by the LUNA technique. More caudally of this fibers, the anastomoses sprouting out of both sympathetic trunks are anastomosing with the pelxus and are responsible for the sensation of fullness of the bladder and of the rectum. Sprouting much more deeper from S2, S3 and S4, the parasympathetic nerves are lies upwards to the pelvic plexus and anastomose to him just caudaly and lateraly to the precedent sympathetic nerves. Thus bladder dysfunction after radical hysterectomy can occure by transection the neural part of the cardinal ligament or by tranesection of the lower part of the inferior hypogastric plexus. It is of importance that the splanchnic pelvic nerves protect them by their pattway in the pelvis: Since the sympathetic nerves are coming directly from above, lesion of them in situation of pelvic prolaps can occure spontaneously by dechirement while the parasympathetic nerves could never been taked under tension since their origin is deeper that the inferior hypogastric plexus. This explain that patient with prolaps of the uterus present offen an bladder retension, but do not feel it painfull, and are able to void their bladder empty so far the uterus is replace in orthotop position.

Based of this new knowledge of pelvic neuroanatomy, we have developped the „nerve-sparing Laparoscopic Assisted Radical Vaginal Hysterectomy“ for therapy of patient with cervical carcinoma as well as the „laparoscopic assisted vaginal parasympathetic-nerve-sparing“ resection of the rectum with deep anterior colorectal anastomosis in extended endometriosis. In both technique we shows a significant reduction of the postoperative functional morbidity (Possover M, Rhiem K. Influence of „parasympathetic-nerve-sparing“ technique in laparoscopic radical pelvic surgery for cervical cancer and for deep infiltrating endometriosis on postoperative bladder dysfunction. Submitted for publication 2004).

This new possibility of an minimal invasive surgical approach of all somatic and autonomous pelvic nerves combined by the LANN open the field of new disciplines, the „laparoscopic pelvic neurosurgery“: We have reported about our first experience of the laparoscopic neurolyse of the sciatic nerve by endometriotic infiltration of the foramen ischiadicus (Possover M. The laparoscopic approach of the pelvic somatic nerves – a new field and dimension of laparoscopic pelvic surgery? Submitted for publication 2004). This new concept of surgical approach
of the pelvic nerves open a new application of pelvic electroneurostimulation and/or neuromodulation since laparoscopic implantation of electrodes do not present particular difficulties for a trained laparoscopic surgeon...