MINIMAL INVASIVE PELVIC NEUROMONITORING – TECHNICAL DEMANDS AND REQUIREMENTS

Kauff DW¹, Koch KP², Hoffmann KP³, Lang H¹, Kneist W¹

¹Department of General, Visceral and Transplant Surgery, University Medicine Mainz, Germany
²Department of Engineering, University of Applied Sciences, Trier, Germany
³Fraunhofer Institute for Biomedical Engineering, St. Ingbert and University of Applied Sciences, Saarbrücken, Germany
daniel.kauff@unimedizin-mainz.de, werner.kneist@unimedizin-mainz.de

Abstract: Intraoperative pelvic neuromonitoring based on observation of bladder and internal anal sphincter innervation enabled accurate prediction of urinary and anorectal functional outcome in patients undergoing open low anterior rectal resection for rectal cancer. The developed method could facilitate primary and secondary prevention of functional disturbances associated with surgical damage of pelvic autonomic nerves. The combination with a minimal invasive approach enabled precise identification, visualization and sparing of pelvic neural pathways. This study aimed to ascertain the technical demands and requirements for a minimal invasive pelvic neuromonitoring.

Keywords: Minimal invasive surgery, intraoperative monitoring, autonomic nervous system, pelvic surgery

Introduction

Two-dimensional intraoperative neuromonitoring (IONM) was recently introduced to open rectal cancer surgery [1]. The developed method enabled verification of bladder and internal anal sphincter (IAS) innervation with accurate prediction of urinary and anorectal functional outcome. Actual short-term outcomes of a first randomised study comparing laparoscopic and open rectal cancer surgery demonstrated similar oncologic results with improved recovery after laparoscopic surgery [2]. The minimal invasive approach in combination with intracorporeal IONM provided more detailed information about the complex distribution of pelvic autonomic nerves, its functional integrity and revealed autonomic neural pathways heading to the lower segment of the rectum [3]. The aim of the present study was to demonstrate further technical demands and requirements for a minimal invasive pelvic IONM.

Methods

A consecutive series of 5 patients (3 females, 2 males) with a median age of 68 (49-89) years undergoing minimal invasive pelvic surgery with IONM were investigated prospectively. Written informed consent was obtained before enrolment. Laparoscopic dissection in the minor pelvis was performed with Ligasure™.

Minimal invasive pelvic IONM was carried out under simultaneous electromyography (EMG) of IAS and manometry of bladder. For EMG of IAS (autonomic innervated smooth muscle) bipolar needle electrodes were inserted under endosonographic guidance (Fig. 1). In addition EMG of external anal sphincter (somatic innervated striated muscle) was performed for differentiation of signal pattern. Bladder manometry was facilitated through the transurethral catheter, which was connected together with the needle electrodes to an adapted IONM system. Thereby, both IONM signals could be observed simultaneously online on the monitor of the device.

Results

Minimal invasive pelvic IONM with the standard procedure was successfully performed in all laparoscopic operations.
Continuous bladder manometry resulted in an unsteady pressure line dependent on the respiratory rate (Fig. 3). The ongoing surgical dissection with LigaSure™ superimposed the EMG signal of IAS (Fig. 4). Recording of intravesical pressure was not affected. Laparoscopic neurostimulation on the left pelvic side could be comfortably performed through the trocar in the lower right abdomen.

### Table 1: Technical demands and requirements for minimal invasive pelvic neuromonitoring.

<table>
<thead>
<tr>
<th>EMG Recording</th>
<th>Actual Status</th>
<th>Demands</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intracorporal Neurostimulation</td>
<td>Insertion of needle electrodes into the IAS under endosonography</td>
<td>Less invasive procedures</td>
<td>Surface electrode arrays facilitating EMG recordings at least as good as the standard procedure</td>
</tr>
<tr>
<td>Extracorporal Neurostimulation</td>
<td>No system for extracorporeal IONM available</td>
<td>Stimulation of pelvic autonomic nerves outside the operation area</td>
<td>Extracorporeal IONM approaches</td>
</tr>
<tr>
<td>EMG Signal of IAS</td>
<td>Frequency adapted online signal processing</td>
<td>Improvement of signal stability</td>
<td>Analysis of human IAS raw signals, other signal displays (e.g. FFT, PSD, rectified RMS)</td>
</tr>
<tr>
<td>Bladder Manometry</td>
<td>Digitalized unsteady intravesical pressure line dependent on respiratory rate</td>
<td>A steady pressure line for accurate assessment of neurostimulation induced increases</td>
<td>Signal processing enabling suppression of respiratory dependent pressure changes (smooth signal)</td>
</tr>
<tr>
<td>Dissection Technique</td>
<td>Dissection artefacts superimposing processed IAS EMG signals</td>
<td>Suppression of artefacts for observation of IAS innervation during ongoing dissection</td>
<td>Online analysis of artefacts and filtering based on identified pattern</td>
</tr>
</tbody>
</table>


**Discussion**

Minimal invasive pelvic IONM is a novel technique providing in combination with the laparoscopic magnification effect further insights into the complex topographical and neuroanatomical distribution of nervous tissue in the minor pelvis. In contrast to open surgery, bladder manometry resulted in a respiratory rate dependent unsteady pressure line, which makes signal interpretation difficult. Currently IONM under EMG of IAS could only be performed with interruption of dissection (e.g. LigaSure™, Harmonic Scapel®, Bipolar Scissors) due to superimposing artefacts. Analysis of raw signals and dissection specific artefacts may enable developments of IONM signal displays with more stability against those artefacts. Apart from desirable software developments, further hardware developments may offer a more minimal invasive pelvic IONM: EMG recordings realised by surface electrode arrays, comfortable neurostimulation through one trocar by flexible probe designs, probes implemented in dissection devices or extracorporeal IONM approaches facilitating neurostimulation outside the operation area. The demanding developments of such new approaches assume cooperation between medical technology and surgery and require a constant exchange of know-how.

**Bibliography**

