Quantification of Catheter and Electrode Displacement During Sensory Assessment in the Lower Urinary Tract Using Fluoroscopy

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Master thesis in Medicine

Background: The cortical recording of sensory evoked potentials (SEPs) during electrical stimulation at different bladder and urethral locations can be used for an appropriate investigation of lower urinary tract (LUT) afferent innervation in healthy subjects and patients. In contrast to conventional somatosensory evoked potential recording using adhesive surface stimulation electrodes at externally accessible locations, the LUT is less accessible, but can be reached by catheter-mounted electrodes. However, in order to integrate LUTSEP recording into clinical practice, factors that could potentially affect LUTSEP measurement variability, should be known and understood to be able to better control such factors. Fluoroscopy allows visual control on the placement of the stimulation catheter at predefined LUT location and to monitor displacement of the relevant stimulation electrodes during electrical stimulation. Aims: The study aim is to determine if and how much the stimulation electrode moves during LUT stimulation. Secondly, we want to assess the impact of gender, stimulation location, and stimulation duration on changes of catheter position. Thirdly, the reliability of catheter position between two separate visits is assessed. Methods: Anterior-posterior (AP) fluoroscopy images were recorded before (pre image) and after LUTSEP stimulation (post image). The pre and post images were superimposed and realigned. In order to measure electrode displacements, a vector was drawn from a stimulation electrode position on the pre to the respective position on the post image. The length of this vector represented the absolute catheter displacement as first outcome parameter. Considering the direction of displacement, a second vector was used, representing the directed catheter displacement along the longitudinal axis of the catheter as second outcome parameter. This vector describes the inward or outward direction of catheter movement in the LUT. After converting from pixels to millimetres, means and standard deviations or medians and ranges were calculated respectively. Moreover, linear mixed models were calculated investigating the impact of different stimulation parameters and subject characteristics on absolute catheter displacement. The data of directed catheter displacement were used to compare two measurement visits by analysing ICC and Bland Altmann plots. Results: The median absolute catheter displacement was 2.3 mm (range: 0-41.4 mm) and the median directed catheter displacement was 0.3 mm (range: 19.1 mm outwards to 41.4 mm inwards) in outward direction. The linear mixed model analysis showed a significant impact of gender and stimulation duration on absolute catheter displacement, but not of stimulation location. However, gender stratified analysis observed a significant catheter displacement at bladder dome compared to urethral locations in female subjects. Directed catheter displacement was more inconsistently in male subjects than in females. Results revealed good agreement between visit 1 and 2 with smaller variability of directed displacement in females compared to males.

Discussion: Despite certain study limitations (retrospective analysis, missing fluoroscopy images, analysis in 2D model etc.), we were able to demonstrate that catheter displacement occurs during LUTSEP measurements and is quantifiable within mm range using fluoroscopic images. Particularly, longer LUTSEP measurement duration and male gender resulted in larger displacements. This finding was expected, since conditions within the LUT do not remain stable. In consequence, longer duration can more easily result in more displacement. Longer urethral configuration and penile movement may contribute to the more pronounced but also more inconsistent catheter dislocation in male participants. Thus, future studies on LUTSEPs should consider and optimize duration of LUTSEP measurements as well as catheter fixation particularly in males. However, although catheter displacement appears rather small, its impact on LUTSEPs is still unclear and requires further investigation. Furthermore, fluoroscopy may not be the single best option for position control of the stimulation catheter in the LUT and alternative options such as sonography should be evaluated.

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