210

Mehnert U[1], Michels L[2], Wöllner J[1], Gregorini F[1], Kurz M[3], Schurch B[1], Kessler T[1], Kollias S[2]
1. *Neuro-Urology, Spinal Cord Injury Center, University of Zurich,* ***2.*** *Institute of Neuroradiology, University Hospital Zurich,* ***3.*** *Department of Urology, University Hospital Zurich*

SUPRASPINAL LOWER URINARY TRACT CONTROL DURING URINE WITHHOLD AND MICTURITION IN HEALTHY MALES – AN FMRI STUDY

Hypothesis / aims of study

Previous neuroimaging studies revealed a number of brain areas involved in lower urinary tract (LUT) control. Most of the investigations focused on the storage phase. Only three positron emission tomography (PET) studies reported about the investigation of cerebral activity during actual voiding [1-3]; yet PET has a poor spatial resolution and little is known about the changes in supraspinal activity, especially in the pontine region, during voiding and withhold of urine. Here we used blood-oxygen-level-dependent (BOLD) functional magnetic resonance imaging (fMRI) to investigate how the activation pattern changes between the switch from voluntary urine withhold to voluntary micturition.

Study design, materials and methods

We included 31 healthy right handed males (18-40 yrs., n = 21 for the fMRI analysis). Pre-existing urological symptoms were excluded by taking the urological history, performing uroflowmetry, and obtaining the IPSS. Each subject had a urinary sheath attached to the penis. The sheath was connected to a special draining tube with an integrated fuid fow measurement device. Before entering the scanner, all subjects received 20 mg furosemide® and were advised to drink water until a strong desire to void occurred. The bladder filling state and the desire to void were assessed before and after fMRI using ultrasound and a visual analogue scale (VAS, e.g. 10 = strongest urge to void) respectively. In order to distinguish supraspinal activity before, during and after initiation of micturition, we divided the functional data into 5 conditions: REST, IMITATE, INITIATE1, INITIATE2, INITIATE3, and URINATE.

Results

The mean IPSS score was 3.3 ±2.76. The urofowmetry showed a mean maximum Flow of 29.3 ±10.1 mL/s and a mean average Flow of 16.0 ±5.8 mL/s. Before entering the scanner, the mean desire to void on the VAS was 7.0 ±1.6 and the mean bladder volume was 514.9 ±307.6 mL. 14 subjects were able to void (= “voider”) during scanning with a mean frequency of 10.2 ±4.3 and a mean volume voided of 240.2 ±195.1 mL. 7 subjects were not able to void (= “non-voider”).
We found signifcant activation of known LUT controlling areas, namely middle and inferior frontal cortices, Thalamus, Pons, Cingulate gyrus, Insula, and Cerebellum, most prominently during INITIATE3 (i.e., before starting micturition) in the group of “voider”. During URINATE, only the anterior cingulate gyrus showed signifcant activation.
The group of “non-voider” did show similar but signifcantly weaker activations during INITIATE3 compared to the group of “voider”, yet there was no activation of the Pons. During IMITATE both groups demonstrated similar activations. No signifcant supraspinal activity was observed during INITIATE1 and 2 in both groups. After scanning, the mean desire to void was 5.8 ±2.5 and the mean bladder volume 893.7 ±406.8 mL.

Interpretation of results

Current models describing the supraspinal network controlling the human LUT seems to be valid, as most of the supraspinal areas used in these models could be shown to be significantly activated during initiation of micturition in this study. Interestingly, highest BOLD signal intensity was observed just before actual micturition, but not during micturition itself. This activity in the supraspinal control network was significantly stronger in the group of “voider” compared to the “non-voider”, who attempted to void, but failed to do so. The disability to void in the scanner might be related to a missing pontine activity in the “non-voider” group during the INITIATE3 condition, which supports the theory that the pontine micturition center is an important structure for the initiation of micturition. However, once micturition is initiated it seems to progress autonomously and does not rely on further pontine input until the bladder is empty or micturition is voluntarily interrupted by contraction of the external urethral sphincter.

Concluding message

Using BOLD-fMRI we were able to demonstrate supraspinal human LUT control during micturition, in which pontine activation seems to be a prerequisite for an effective initiation of micturition. Once micturition started, the BOLD signal decreased in all previously activated areas, suggesting that micturition is initiated supraspinally but maintained on spinal level only, once “authorized” by the supraspinal centers, in particular by the Pons.

References

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