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BRAIN REGIONS AND EFFECTIVE CONNECTIVITY IN VOLUNTARY CONTROL OF BLADDER SENSATIONS: AN FMRI STUDY

Hypothesis / aims of study

Urinary bladder sensations are influenced by individual and situational factors. The desire to void can be suppressed, but it can also be called forth deliberately as far as maximum bladder capacity is not reached. A previous fMRI study identified several brain regions (the supplementary motor area (SMA), the cingulate cortex, the prefrontal and posterior parietal cortex, the insula and frontal operculum) to be more active during "attempted micturition" than during suppression of bladder sensations.[1] The aims of the present study were to localise brain regions that are active when micturition is brought forward, to test for gender-related differences and to analyse the effects of different bladder volume. In addition we explored the effective connectivity of cortical regions involved in task-related bladder control.

Study design, materials and methods

We studied brain activity during intentional modulations of bladder sensation in 33 healthy volunteers (17 women, 16 men). Exclusion criteria comprised neurological or psychiatric disease, symptoms of urinary tract infection or incontinence, or any other problems that precluded being scanned by the 1.5 Tesla tomograph. The age of the participants was 26.4 +/- 4.2 years (mean +/- SD). They were instructed not to void for about 120 min. prior to the fMRI experiment. All subjects stated that they had a latent desire to void. In the baseline (B) task, the subjects repressed the desire to void. During the urge (U) task ("attempted micturition"), they concentrated on bladder sensations and called forth the urge to void as if initiating micturition. A tonic voluntary contraction of the pelvic floor muscles terminated the U-task. Two functional imaging runs including five repetitions of the B- and U-task were performed with a full bladder. After the following micturition, another two functional imaging runs were repeated, which represent a low-bladder-volume condition. Finally, the participants emptied their bladder again to measure urine volume. The images were processed and analysed with the SPM2 software. Functional images were motion corrected, anatomically standardised, reconstructed with a voxel size of 3x3x3 mm, and smoothed with a 7 mm (FWHM) Gaussian filter. Brain activations associated with "attempted micturition" were identified by subtracting the urge U- and B-tasks. A reverse subtraction detected deactivations. The contrast images of all subjects were entered into a second-level random-effects analysis. Overall responses (regardless of bladder volume) were determined with a one-sample *t*-test. Data from men and women were contrasted with a *t*-test for independent samples. To assess the effects of the bladder volume, a paired *t*-test was used to compare task-related activations. Psychophysiological interaction (PPI) analyses were performed to assess changes in effective connectivity during "attempted micturition" and were first conducted for each subject. The resulting contrast images underwent a second-level group analysis. Significant target regions were determined by one sample *t*-tests.

Results

The supplementary motor area, midcingulate cortex, insula, frontal operculum, and right prefrontal cortex were consistently more active when the desire to void was enhanced without allowing urine to pass ("attempted micturition") than during a baseline task when bladder sensations were suppressed. The right anterior insula and midbrain periaquaeductal grey (PAG) were more active at higher than at lower bladder volumes. Responses of the right thalamus and several other right hemispherical regions were stronger in women than in men. Using the psychophysiological interaction (PPI) method, we found that the midcingulate cortex had stronger connectivity (indicated by parallel co-variations of the activation time series) with the PAG and medial motor areas during "attempted micturition" than during the baseline task. On the other hand, during U-task the left and right insula showed decreased connectivity with many other brain regions, including bilateral middle frontal, posterior parietal and temporal cortices which signals decreased when the source (insular) signals increased.

Interpretation of results

Intentional modulations of the desire to void seem to change the effective connectivity of supraspinal regions involved in bladder control. In contrast to the baseline task, the enhanced midcingulate cortex connectivity (with PAG and medial motor areas) during "attempted micturition", possibly reflects monitoring of urethral sphincter muscle contractions. The decreased connectivity of the left and right insula during the U-task, might be due to predominant processing of bladder afferent input.

Concluding message

In both sexes, a set of frontoparietal brain regions, including the SMA, the midcingulate cortex, the bilateral insula, the frontal operculum, and the right prefrontal cortex are involved in voluntary bladder control. However, gender related differences are detectable. Intentional modulations of the desire to void change the effective connectivity of supraspinal regions involved in bladder control.

References

1. Kuhtz-Buschbeck et al. 2005; J. Urol 174

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