Quantification of Cerebral Blood Flow During Bladder Filling in Healthy Subjects

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Introduction

- Urine storage and emptying is a complex physiologic process under the control of the central nervous system
- The micturition pathway has been studied through various functional brain imaging studies
- However, how brain activity changes as bladder volume and bladder sensations change remains unclear
- The aim of our study is to quantify cerebral perfusion and change in brain activity in healthy subjects during bladder filling

Methods

- Healthy women without overactive bladder were recruited to undergo functional magnetic resonance imaging (fMRI) during bladder filling
- Bladder filling was performed by infusing saline into the bladder at a rate of 50ml/s through a foley catheter
- During bladder filling, subjects were given a response button to signal: first sensation of bladder filling, first desire to void, and strong desire to void
- Scans were performed at set bladder volumes: 0mL, 50mL, 100mL, 200mL, 350mL, and 500mL
- Institutional IRB approval was obtained prior to initiation of the study

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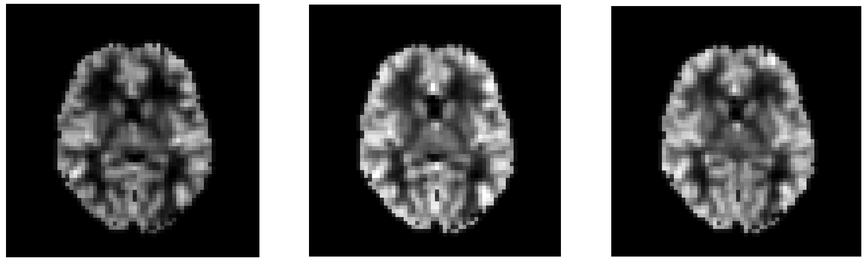
Results



Baseline | First desire to void | Strong desire to void

Figure 1: fMRI images of a subject obtained at baseline and during bladder filling

Region of Interest	Normalized Cerebral Blood Flow				
	Baseline	First desire to void	Strong desire to void	Δ(First desire - baseline)	Δ(Strong desire - first desire)
Rt. ACC	0.89 ± 0.06	0.92 ± 0.08	0.90 ± 0.09	0.03 ± 0.04 *	-0.02 ± 0.07
Lt. ACC	0.96 ± 0.08	0.98 ± 0.09	0.89 ± 0.11	0.03 ± 0.06	-0.07 ± 0.10
Rt. DLPFC	1.71 ± 0.21	1.63 ± 0.18	1.59 ± 0.19	-0.07 ± 0.11	-0.05 ± 0.07
Lt. DLPFC	1.30 ± 0.28	1.26 ± 0.26	1.33 ± 0.19	-0.04 ± 0.10	0.02 ± 0.16
Rt. Hippocampus	0.99 ± 0.08	1.02 ± 0.08	0.98 ± 0.16	0.03 ± 0.07	-0.04 ± 0.10
Lt. Hippocampus	0.91 ± 0.07	0.91 ± 0.07	0.87 ± 0.11	0.00 ± 0.06	-0.05 ± 0.05 *
Rt. Insula	1.06 ± 0.09	1.10 ± 0.11	0.99 ± 0.13	0.04 ± 0.05 *	-0.10 ± 0.09 *
Lt. Insula	0.90 ± 0.05	0.95 ± 0.06	0.88 ± 0.08	0.04 ± 0.03 **	-0.07 ± 0.06 **
Rt. PCC	0.83 ± 0.07	0.83 ± 0.07	0.79 ± 0.09	0.01 ± 0.04	-0.04 ±0.04 *
Lt. PCC	0.92 ± 0.07	0.92 ± 0.08	0.89 ± 0.09	0.00 ± 0.03	-0.03 ± 0.04
Rt. Pons/midbrain	1.08 ± 0.11	1.10 ± 0.11	1.08 ± 0.13	0.03 ± 0.05	-0.04 ± 0.07
Lt. Pons/midbrain	1.08 ± 0.12	1.10 ± 0.12	1.07 ± 0.12	0.02 ± 0.06	-0.03 ± 0.09
Rt. SMC	1.04 ± 0.12	0.99 ± 0.08	1.04 ± 0.15	-0.04 ± 0.06 *	0.03 ± 0.11
Lt. SMC	0.95 ± 0.14	0.89 ± 0.11	0.96 ± 0.18	-0.05 ± 0.06 *	0.06 ± 0.13
Rt. SMA	1.21 ± 0.09	1.19 ± 0.07	1.22 ± 0.10	-0.02 ± 0.06	0.01 ± 0.09
Lt. SMA	1.04 ± 0.12	1.02 ± 0.14	1.07 ± 0.16	-0.02 ± 0.07	0.03 ± 0.10
Rt. Thalamus	0.81 ± 0.06	0.83 ± 0.06	0.80 ± 0.08	0.02 ± 0.05	-0.02 ± 0.05
Lt. Thalamus	0.87 ± 0.06	0.89 ± 0.08	0.86 ± 0.08	0.03 ± 0.05	-0.03 ± 0.04

Table 1: Cerebral blood flow (CBF) values normalized to the global average at baseline (0mL), for first desire and strong desire states in 18 regions of interest, all previously demonstrated to have a role in micturition pathway[1,2]. * denotes p<0.05 and ** denotes p<0.01.

Results

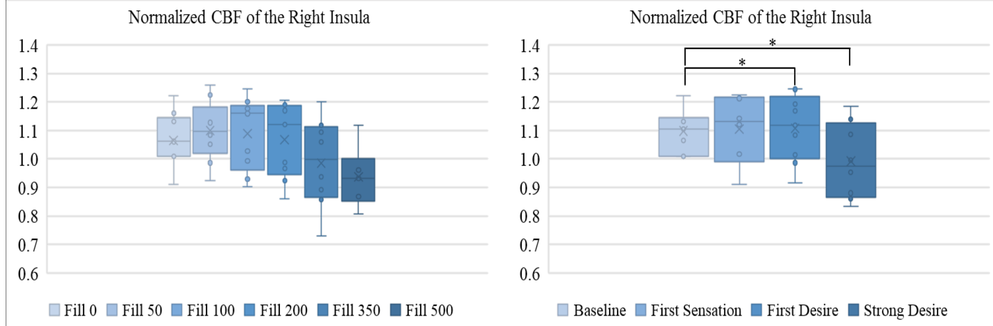


Figure 2: Box plots of normalized cerebral blood flow (CBF) in the right insula.
* denotes p<0.05.

Results

- Increased CBF at first desire to void was seen in the insula, and right anterior cingulate cortex
- Decreased CBF at first desire to void was seen in the supplemental motor cortex
- Decreased CBF at strong desire to void seen in the insula, right posterior cingulate cortex, and left hippocampus

Brain Region	Known Function
Insula	Visceral sensation
Hippocampus	Consolidate short term memory to long term memory, spatial memory
Anterior cingulate cortex	Emotional response, motivational behavior
Posterior cingulate cortex	Emotion, memory, attention, meditation
Supplemental motor cortex	Coordination of movement

Conclusion

- Regional brain perfusion during bladder filling can be objectively quantified
- These data may serve as a reference point for future studies investigating normal and abnormal bladder function
- Unclear what role the brain regions of interest may play during filling
- Our results support the hypothesis that cerebral blood flow increases as the desire to void increases until it reaches a critical point and decreases to potentially suppress desire to void[3]

References

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