

Effects of Epidural KiloHertz Frequency Spinal Cord Stimulation on Lower Urinary Tract Function in a Rat Spinal Cord Transection Model

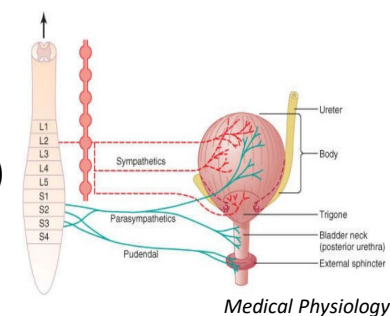
Casey J. Steadman, Chris L. Langdale, and Warren M. Grill

Duke University, Department of Biomedical Engineering

Introduction

Spinal cord injury (SCI) results in bladder dysfunction¹

- Neurogenic Detrusor Overactivity (NDO)
- Detrusor spinctor dyssnergia (DSD)
- Impaired Bladder Emptying



Medical Physiology

Epidural kilohertz frequency spinal cord stimulation (KHF SCS) is capable of modulating lower urinary tract function in intact rats, as well as following the instillation of acetic acid into the bladder to induce hypersensitivity, mimicking the effects seen after SCI².

Intact → Increases in bladder capacity, voiding efficiency, and external urethral sphincter (EUS) EMG

Hypersensitive → Increases in Voiding Efficiency and EUS EMG amplitude + Decreases in the number of non-voiding contractions

The aim of this study is to determine the effectiveness of KHF SCS to suppress NDO and DSD following SCI.

Methods

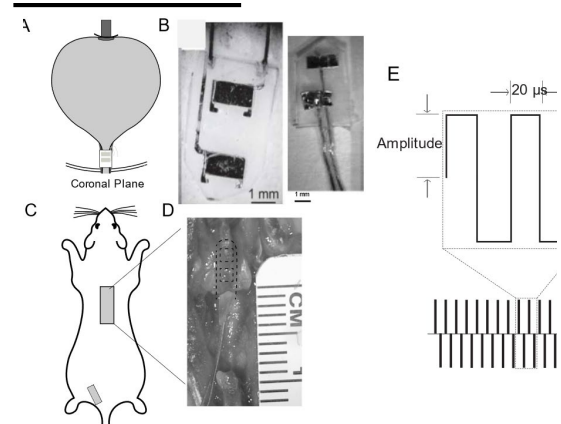


Figure 1. Experimental Design (A) Schematic of cystometry and EUS EMG set-up. (B) Paddle electrodes for recording EUS EMG (left) and stimulating the spinal cord (right). (C, D) Placement diagram for spinal cord paddle electrode. (E) Pulse width and stimulation pattern. Stimulation was continuous during bladder filling.

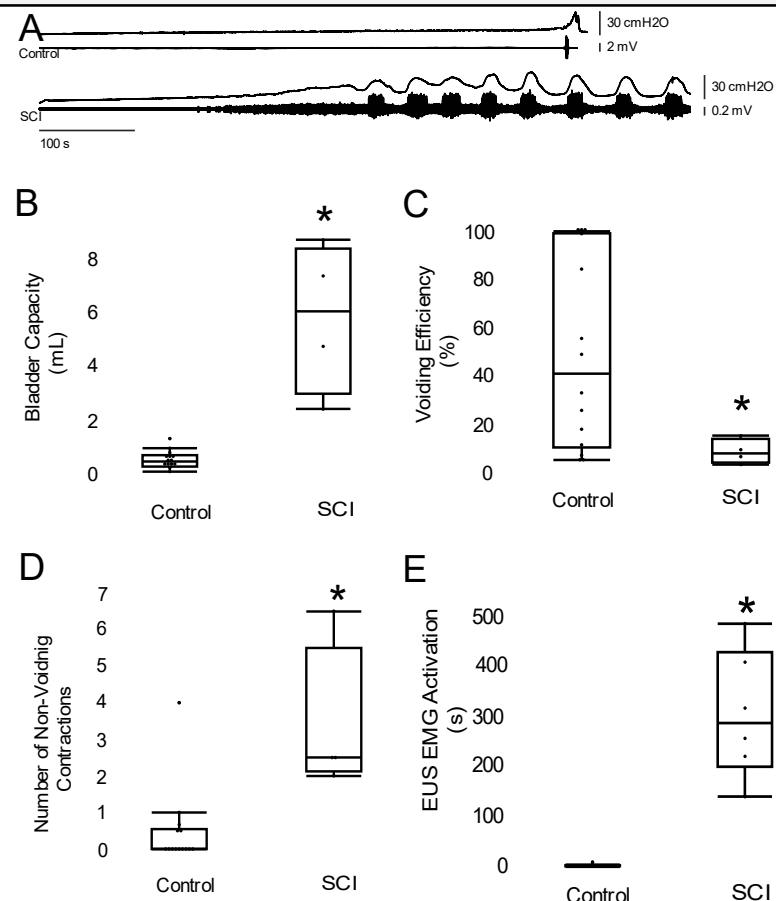
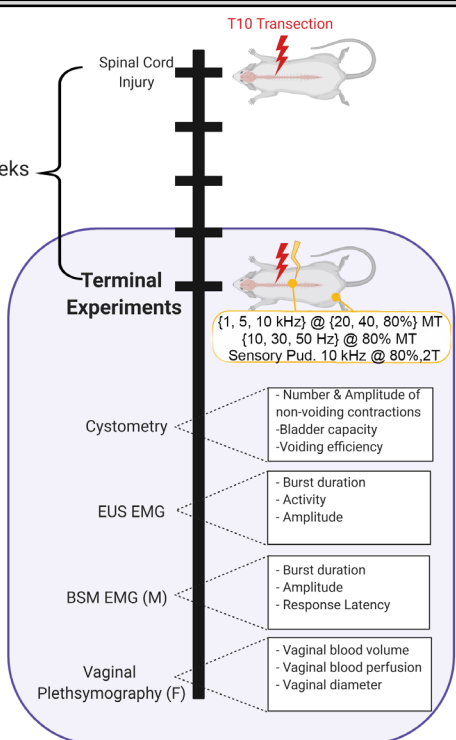


Figure 2. Bladder Outcome Measures in Intact versus T10 transection SCI rats. (A) Representative trace of bladder pressure and EUS EMG of a spinally intact (top) and spinally transected (bottom) rat. After spinal transection, (B) bladder capacity was increased, (C) voiding efficiency was decreased, (D) the number of non-voiding contractions was increased, and (E) the duration of EUS EMG activity during filling and voiding was increased.

Conclusions

- Intact rats → KHF SCS **increases bladder capacity, voiding efficiency, EUS EMG amplitude, and decreases non-voiding contractions.**
 - Afferent feedback from EUS is **excitatory**
- After SCI → **tonic EUS activity** causes **increased bladder capacity, non-voiding contractions, and decreased voiding efficiency.**
- KHF SCS after SCI → **decreases tonic EUS activity** allowing for **decreases in bladder capacity, non-voiding contractions, and increases in voiding efficiency.**
 - Afferent feedback from EUS is **inhibitory?**
- **Potential mechanism of action** → modulating afferent input from the bladder/EUS

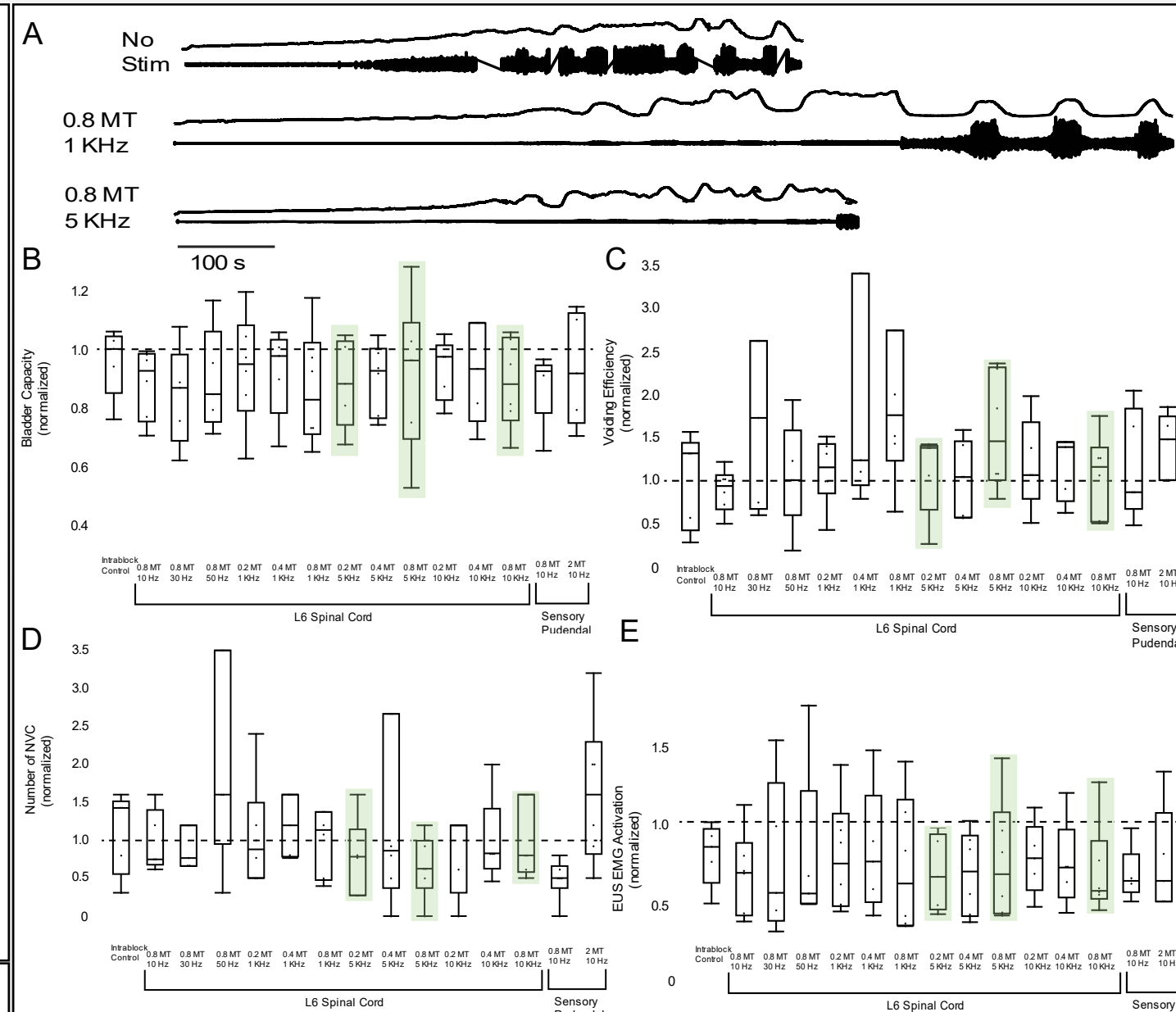


Figure 3. Bladder Outcome Measures with epidural KHF SCS in T10 transection SCI rats. (A) Representative trace of bladder pressure and EUS EMG of a spinally transected rat with no stimulation (top), with epidural SCS of 1 kHz at 80% of motor threshold (middle), and with epidural SCS of 5 kHz at 80% of motor threshold. When normalized to pre-stimulation controls, KHF SCS (B) decreased bladder capacity, (C) increased voiding efficiency, (D) decreased the number of non-voiding bladder contractions dependent on the parameter used, and (E) decreased the duration of EUS EMG activity. The dashed line represents pre-stimulation controls, and green shading highlights the top 3 parameters determined to be effective in spinally intact rats both with and without acetic acid cystometry.

Acknowledgements

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References

1. Weld KJ, Dmochowski RR (2000) Association of level of injury and bladder behavior in patients with post-traumatic spinal cord injury. *Urology* 55:490-494.
2. Steadman CJ, Langdale CL, and Grill WM (2020) Effect of Epidural KiloHertz Frequency Spinal Cord Stimulation on Lower Urinary Tract Function. In preparation.