Anatomical Sciences and Neurobiology

Multispecies Urodynamic Study Comparing Void Patterns in Spinally Intact and Contused Rats, Minipigs, and Humans

KENTUCKY SPINAL CORD INJURY RESEARCH CENTER

DANIEL MEDINA-AGUINAGA[1], RAKIB AMHED UDIN[2], UZOMA ANELE[3], STEVEN DAVISON[2], MAXWELL BOAKYE[2, 4], CHARLES HUBSCHER[1,5].

[1]Dept. Anatomical Sciences & Neurobiology, University of Louisville School of Medicine, Louisville, KY, USA; [2]Boakye Spinal Cord Injury Lab, University of Louisville School of Medicine, Louisville, KY, USA; [3]; Department of Urology, Louisville, KY, USA; [4]Department Neurological Surgery, University of Louisville, Louisville, KY, USA; [5] Kentucky Spinal Cord Injury Research Center, Louisville, KY, USA

Introduction

The rodent as well as larger animal models are widely used for investigations of the pelvic floor and LUT function after spinal cord injury. Due to the differences of the external urethral sphincter activity during voiding between the non-human animals and the human beings, the translational value of such models has been questioned. The aim of this study was to explore and evaluate bladder function in the lower urinary tract (LUT) under normal conditions and after SCI in Human beings, Yucatan mini-pigs and rats performing urodynamic studies under fully awake/ conditions yields similar characteristics that are present in all urinary cycle phases found in human studies for both non-injured and post-injury conditions.

Methodology

. All urodynamic studies in animal models were conducted under awake conditions. Fill-void cycles were examined in non-injured male rats and in SCI male rats three weeks post severe T9 contusion (Infinite Horizon Impactor). Bladder pressure (CMG) and electromyographic data (EUS, EMG) were amplified with a 4-channel pressure amplifier (WPI Transbridge 4 M amplifier) and a 4-channel differential AC amplifier (AM-Systems, model 1700) Yucatan minipigs underwent urodynamics prior to injury and twelve weeks post T10 severe contusion SCI. To evaluate bladder function, a sterile T-Doc® air-charged 7Fr single sensor with filling lumen (CAT895, Laborie, VT, USA). The clinical urodynamic records from male patients were obtained from published literature (1, 2) and analyzed for both non-injured conditions and after SCI.

Results

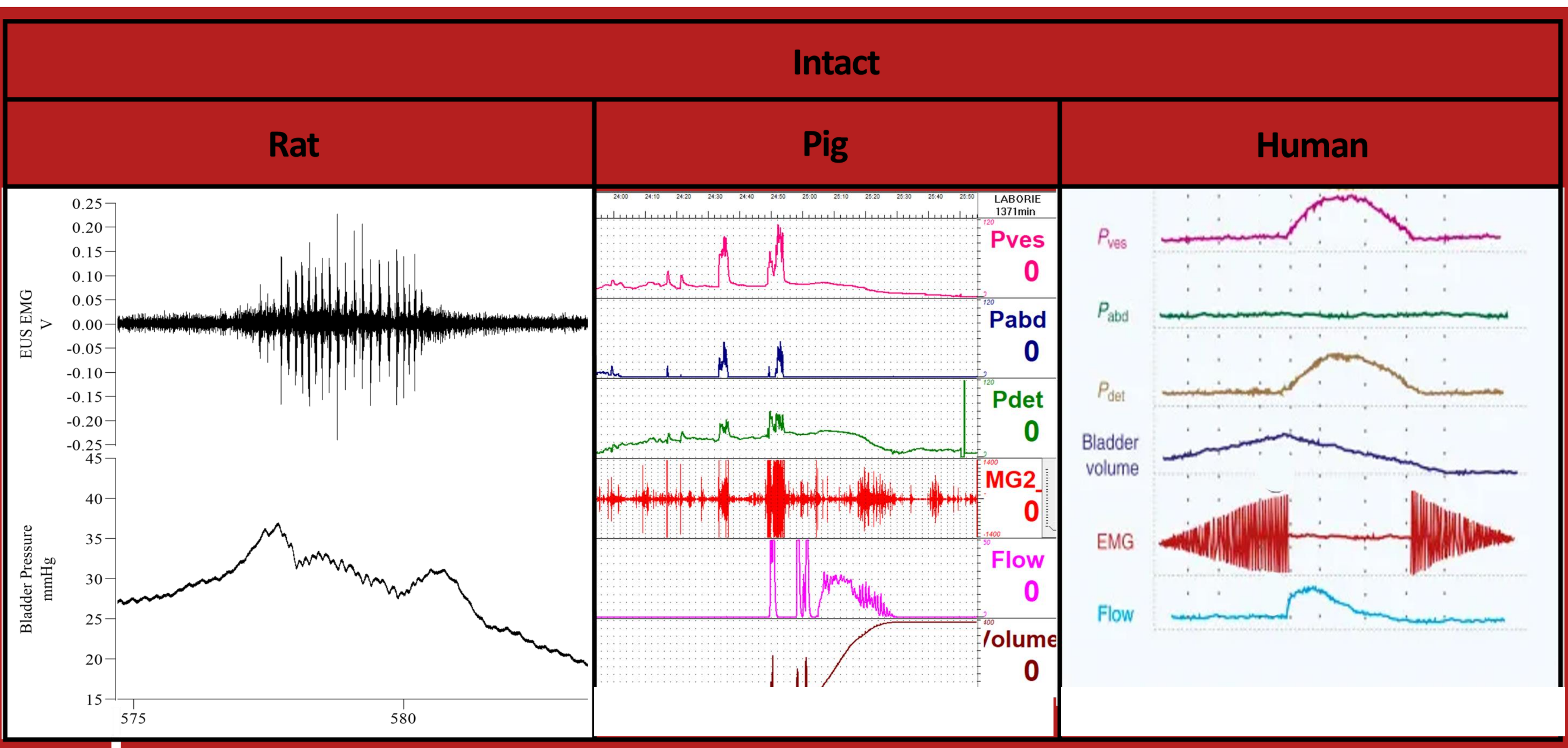

Figure 1.- Examples of cystometric and electromyographic (CMG-EMG) activity in intact rats, pigs and humans. During the void phase in rats, preinjury urodynamics shows an initial rise in intra-vesical pressure (Pves), followed by phasic contractions of the EUS which provokes sudden and rhythmic Pves increases, and the expulsion of urine followed by Pves decrease. In mini-pigs, a continuous bell-shaped curve with slight to moderate right asymmetry of the bell including rhythmic intermittence of the flow accompanied by a bursting-like firing of the EUS during the last third of the contraction was seen. In healthy humans, a continuous bell-shaped contractile curve during voiding accompanied by very low EMG activity and continuous urine flow was found (1).

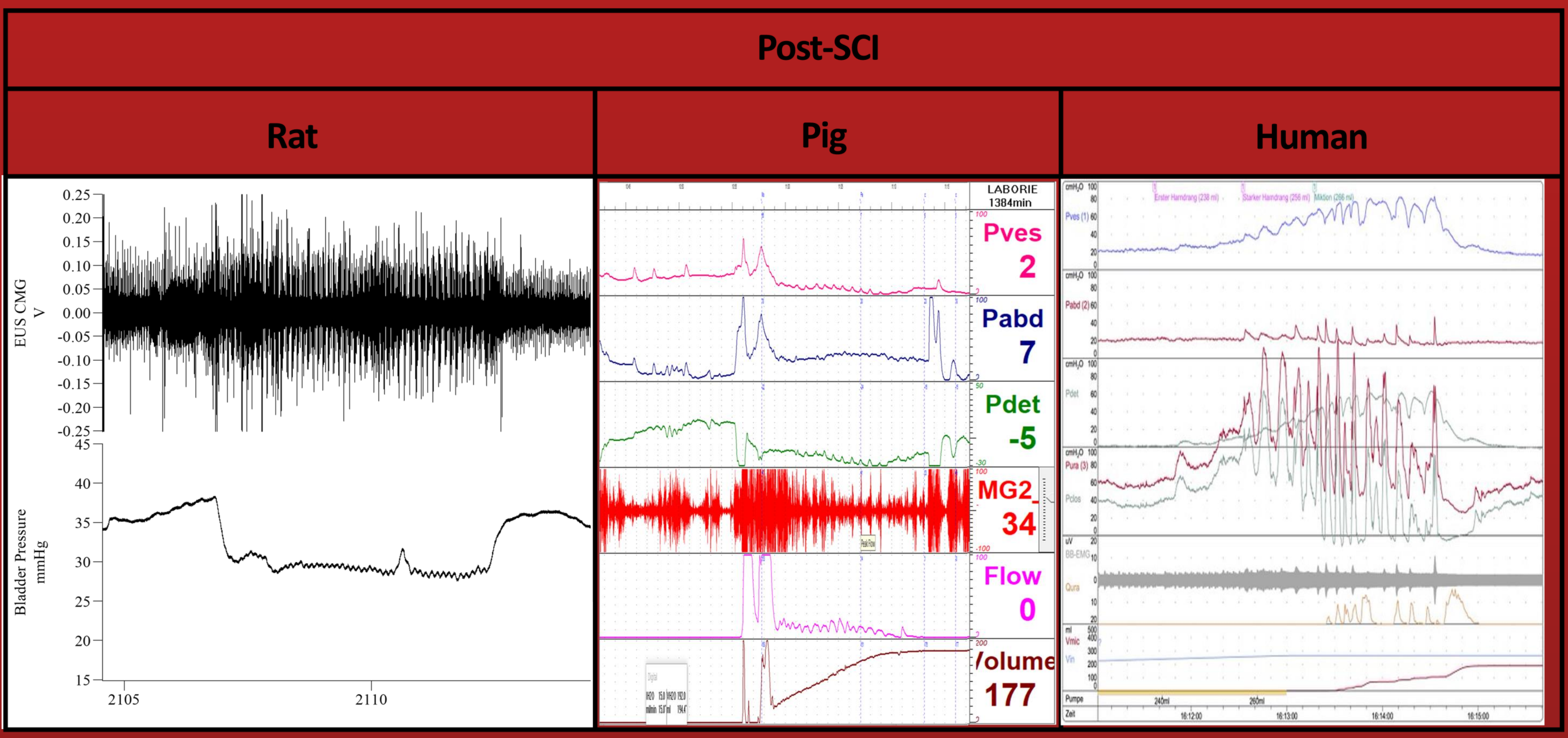

Figure 2.- Examples of cystometric and electromyographic (CMG-EMG) activity in spinal cord injured rats, pigs and humans. In rats, the pattern of the CMG and EMG was like the pre-injured conditions but with larger void duration, an increase in the bursting frequency and a reduction on the active-silent ratio of the bursting. In mini-pigs, an increase in abdominal pressure before the void, bursting activity of the EUS during the expulsion of urine, and low intermittent flow rate was found. The image shown for the human is an example of a patient with DSD type 2 (2) . Note the similarities between human and pig cystometry.

Conclusion

The urodynamic studies show the differences of EUS activity during the voiding in humans (silent) compared with rats and pigs (intermittent) in intact animals. The existence of a lumbar spinal coordinating center (LSCC) at L3-L4 spinal level has been shown in rats as responsible for the intermittent bursting pattern of the EUS, making possible the existence of a similar structure in pigs.

After SCI, all species showed EUS intermittency, suggesting the presence of comparable neural circuitries between rats, pigs and humans below the level of injury, including corresponding plasticity and pathologic processes after SCI. We hypothesize the existence of a structure like the LSCC in humans which becomes silent after toilet training during early development in humans but becomes active after SCI and is responsible for the emergence of DSD type 2.

Acknowledgements

The authors thank Monique Morgan, Destiny Gibson, Jackson Gallagher and Emily Macaluso for technical assistance, and Landry Konan for surgical assistance. Protocols were reviewed and approved by the IACUC committee at the University of Louisville School of Medicine.