Diabetic Complications Consortium

Application Title: MRI-Urodynamic Evaluation of Early Changes in Diabetic Cystopathy.

Principal Investigator: Alejandro Roldán-Alzate

1. Project Accomplishments:

- A total of Twelve (12) healthy volunteers have been recruited for the study including four six (6) men and three (6) women. Two (2) patients with diabetes were recruited and two (2) more are scheduled to be scanned later in July 2023. Data analysis is currently being conducted as more subjects are recruited. Recruitment of diabetic patients has been slower than anticipated.
- The MRI technology that we have implemented has allowed us to obtain quantitative and qualitive data about the lower urinary tract providing specific and varied information about anatomy and biomechanics during the voiding process in a safe, accurate and reproducible way (Figure 1).
- Correlations between different metrics have been obtained.
- Computational simulations based on MRI results have been performed and compared to metrics obtained with multichannel urodynamics.
- In vitro validation has been conducted using an anatomically realistic model of the human bladder (Figure 2).

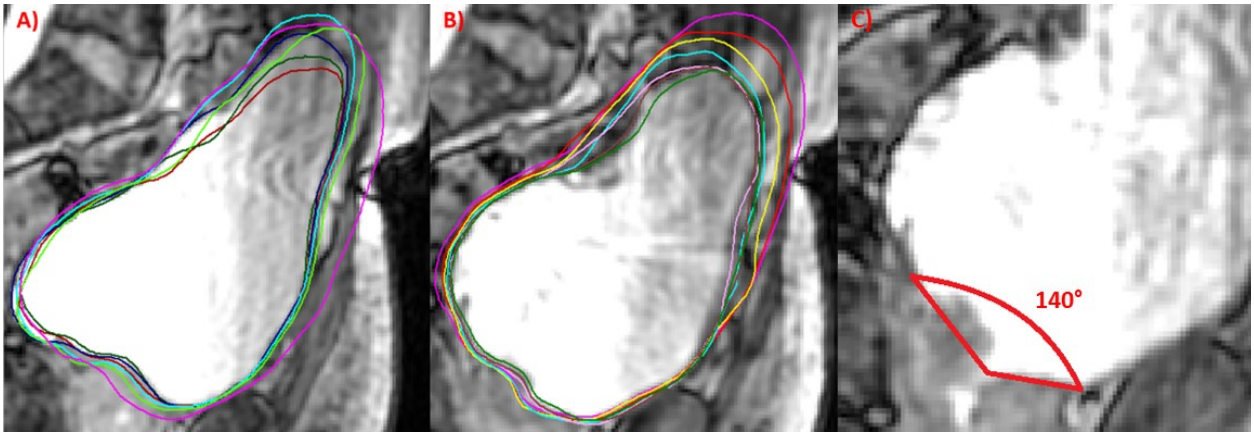

Figure 1: a) Contour lines of bladder lumen segmentations though the voiding event. b) Bladder emptying prolapse distance and c) EBNA at maximum flow rate for a healthy volunteer.

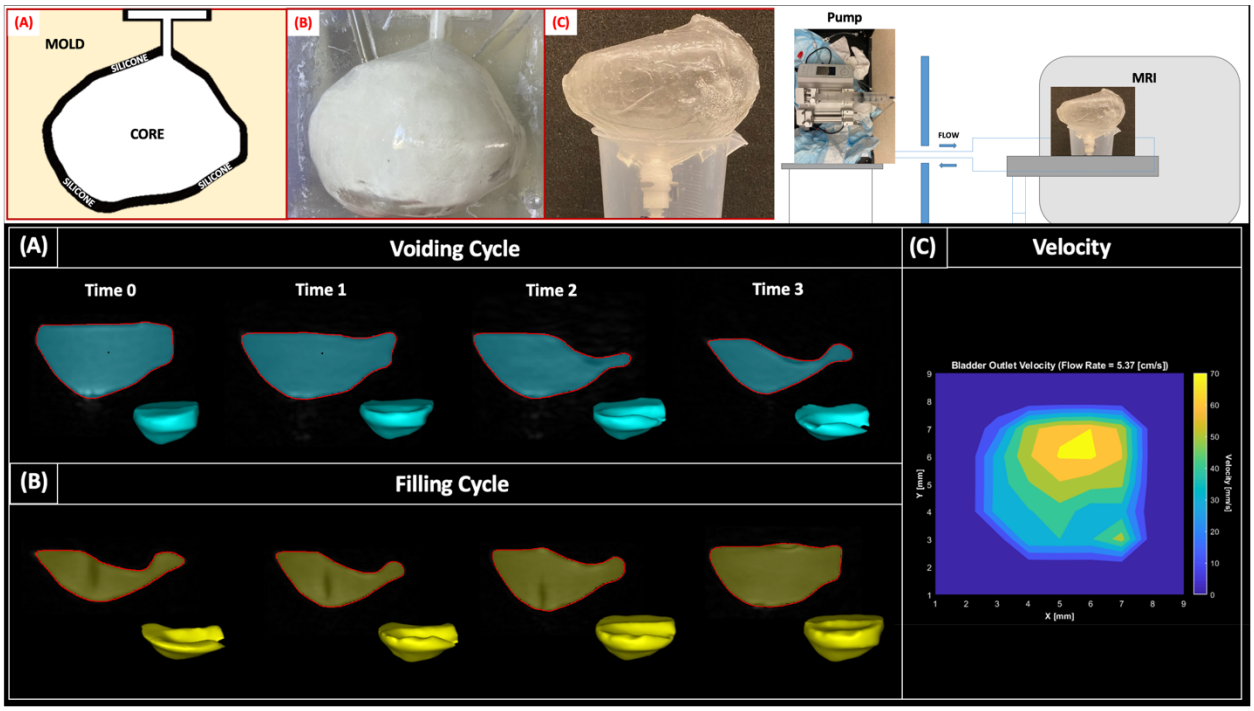

Figure 2: ***In Vitro validation of MRI urodynamics.***

- Further investigations into this technique will focus on establishing a healthy baseline for the biomechanics of Lower Urinary Tract (LUT). This information can then be compared with patients with diabetes-related LUT conditions and lead to earlier diagnosis and more specific treatment which is informed directly by their anatomical and biomechanical characteristics.
- Fourteen (14) conference abstracts (listed below) were presented at international conferences.
- Three journal articles focusing on MRI method implementation and MRI based computational modeling for bladder and urethral flow dynamics are in preparation or in review.

2. Specific Aims:

Specific Aim 1. Perform dynamic MR imaging of voiding in young men with type 1 diabetes and age-matched healthy controls.

Six healthy control men and one male patient with diabetes have been recruited for the study.

Specific Aim 2. Perform dynamic MR imaging of voiding in young women with type 1 diabetes and age-matched healthy controls.

Six healthy control woman and one female patient with diabetes have been recruited for the study.

3. Publications:

1. Rice, J., Gwertzman, J. and Roldan-Alzate, A. Towards enhanced non-invasive assessment of bladder urodynamics – validation of dynamic 3D MRI in a patient-specific in vitro model of the bladder. SB*3*C2023, Vail, CO. (2023). Oral Presentation & ASME-BED Ph.D. Competition Finalist.

2. Rice, J., Gwertzman, J. and Roldan-Alzate, A. Enhanced assessment of urodynamics in a patient-specific, in-vitro model of the bladder using dynamic 3D MRI and particle image velocimetry. EUS, Chicago, IL. (2023). Oral Presentation & Best Paper Award Winner.

3. Shahid, L., Gonzalez-Pereira, J. P., Johnson, C., Li, Y., Rowinski, D., Roldán-Alzate, A. Simulating Bladder Voiding Using Real-Time MRI-Based Computational Fluid Dynamics: A Pilot Study. In: Proceedings of the 2022 O'Brien Center Annual Symposium. 2022 29-30 June; Madison, WI, USA

4. Shahid, L., Gonzalez-Pereira, J. P., Johnson, C., Bushman, W., Roldán-Alzate, A. Computational Fluid Dynamics of Bladder Voiding Using 3D Real-Time MRI. In: Engineering and Urology Section of the Endourolgical Society (EUS), 2023 Annual Meeting of the American Urological Association. 2023 28-01 April-May; Chicago, IL, USA.

5. Johnson, C., Gonzalez-Pereira, J., Shahid, L., Wells, S., Bushman, W., & Roldán-Alzate, A. Dynamic MRI Reveals a Change in Prostatic Urethral Angle During Voiding. In: Proceedings of the 2023 Annual Meeting of the American Urological Association. 2023 28-01 April-May; Chicago, IL, USA.

6. Johnson, C., Kounga, M., Gonzalez-Pereira, J., Wells, S., Bushman W., & Roldán-Alzate, A., The Analysis of Urethral Biomechanics During Voiding Using MRI. In: Proceedings of the 2022 O'Brien Center Annual Symposium. 2022 29-30 June; Madison, WI, USA.

7. Kounga, M., Johnson, C., Gonzalez-Pereira, J., Wells, S., Bushman W., & Roldán-Alzate, A. The Analysis of Urethral Biomechanics During Voiding Using MRI [abstract]. In: Proceedings of the 2022 Summer Biomechanics, Bioengineering, and Bio transport Conference. 2022 20-23 June; Cambridge, MD, USA

8. Gonzalez-Pereira, J. P., Johnson, C., Wells, S. A., Bushman, W., Roldán-Alzate, A. (2022, June 29-30). *Assessment of bladder biomechanics using MRI* [Conference Presentation]. 2022 O'Brien Center Annual Symposium, Madison, WI, United States. https://obrien.urology.wisc.edu/2022-obrien-center-annual-symposium/

9. Gonzalez-Pereira, J. P., Shahid, L., Wells, S. A., Bushman, W., Roldán-Alzate, A. (2022, November 10-13). *Investigation of Bladder Biomechanics Using Dynamics MRI and Computational Fluid Dynamics* [Conference Presentation]. 2022 SBUR Annual Meeting, Orlando, FL, United States. https://sbur.org/event/2022-sbur-annual-meeting/

10. Gonzalez-Pereira, J. P., Shahid, L., Wells, S. A., Bushman, W., Roldán-Alzate, A. (2022, November 10-13). *Dynamic MRI Reveals a Change in Prostatic Urethral Angle During Voiding* [Conference Presentation]. 2022 SBUR Annual Meeting, Orlando, FL, United States. https://sbur.org/event/2022-sbur-annual-meeting/

11. Gonzalez-Pereira, J. P., Johnson, C., Wells, S. A., Bushman, W., Roldán-Alzate, A. (2023, June 4-8). *Bladder Biomechanics – Filling and Voiding* [Conference Presentation]. SB3C: Summer Biomechanics, Biotransport, Bioengineering, Vail, CO, United States. https://sb3c.org/

12. Gonzalez-Pereira, J. P., Wells, S. A., Bushman, W., Roldán-Alzate, A. (2023, April 30). *Investigation of Bladder Biomechanics Using Uro-Dynamic MRI* [Conference Presentation]. EUS: Engineering & Urology Society, Chicago, IL, United States. https://engineering-urology.org/

13. Gonzalez-Pereira, J. P., Johnson, C., Wells, S. A., Bushman, W., Roldán-Alzate, A. (2022, May 7-12). *MRI Urodynamics: A 3D approach to bladder biomechanics* [Conference Presentation]. Joint Annual Meeting ISMRM-ESMRMB, London, England, UK. https://www.ismrm.org/22m/

14. Gonzalez-Pereira, J. P., Johnson, C., Wells, S. A., Bushman, W., Roldán-Alzate, A. (2022, June 20-23). *Assessment of bladder biomechanics using MRI* [Conference Presentation]. SB3C: Summer Biomechanics, Biotransport, Bioengineering, Cambridge, MD, United States. https://sb3c.org/

Journal Articles (In review/preparation)

1. Gonzalez-Pereira, J. P., Johnson, C., Wells, S. A., Bushman, W., Roldan-Alzate, A. Technical Feasibility of Uro-Dynamic MRI Study of Voiding Biomehcanics [Under Review]. International Urology and Nephrology.

https://www.springer.com/journal/11255/

2. Shahid, L., Gonzalez-Pereira, J. P., Johnson, C., Bushman, W., Roldán-Alzate, A. MRI Urodunamics - Computational Fluid Dynamics of Bladder Voiding. In preparation for submission to: Nature – Scientific Reports

3. Johnson, C., Kounga, M., Gonzalez-Pereira, J., Wells, S., Bushman, W., & Roldán-Alzate, A., "Non-Invasive Analysis of Urethral Biomechanics During Voiding Using MRI" In preparation for submission to: Neurourology & Urodynamics.