Decreasing Arterial Flow in the Ex Vivo Functional Pig Bladder Model Demonstrates Preservation of Tissue Oxygenation and Non-linear Decrease in Perfusion Pressure: Potential Mechanisms for Underactive Bladder and Vascular Autoregulation

Uzoma Anele MD1, Andrew Tracey MD1, Andrew Colhoun MD1, Randy Vince MD1, John E Speich PhD2, Paul Ratz PhD3, and Adam P Klausner MD1

1Department of Surgery/Division of Urology, Virginia Commonwealth University School of Medicine, Richmond, VA 2Department of Mechanical & Nuclear Engineering, Virginia Commonwealth University School of Engineering, Richmond, VA 3Department of Biochemistry and Molecular Biology, Virginia Commonwealth University School of Medicine, Richmond, VA

Abstract ID: 18-9405

INTRODUCTION

Chronic ischemia is a recognized factor in the pathophysiology of underactive bladder (UAB). Although relative ischemia is known to occur during filling, little is known regarding the pathophysiology that leads to UAB. Therefore, we developed an ex vivo functional porcine model to investigate the role of transient ischemia and whether autoregulation, a mechanism that maintains tissue oxygenation in certain vital organs, also exists in the bladder.

METHODS

Using bladders from slaughtered pigs, we prepared an isolated perfused model where we studied the effects of bladder perfusion flow rate on perfusion pressure and tissue oxygenation during the filling phase. Bladders were perfused at an initial flow rate of 20 ml/min and then clamped in a sequentially decreasing stepwise manner down to no flow and back to the initial flow rate.

RESULTS

Figure 1. Experimental setup with bladder preparation.

Figure 2. Example of autoregulation of blood flow. There is a blood pressure range in which blood flow is maintained through active changes in blood vessel diameter.

Figure 3. Representative tracing of flow rate modulation and corresponding perfusion pressure. As flow rate was decreased, a corresponding decrease in perfusion pressure was observed. Perfusion pressure was maintained until flow rate was returned to baseline when flow rate is returned to 20 ml/min.

Figure 4. Observation in bladder (n=3) with baseline flow set to 20 ml/min. A) Fold change in initial perfusion pressure to steady-state. When flow was decreased below 5 ml/min, there was a significant decrease in the ratio of steady to initial state perfusion pressure compared to baseline. B) Relationship between average perfusion pressure and flow rate. There was an inverse linear correlation between pressure and flow rate; however, this relationship (dependence) changed below 5 ml/min. The ratio of steady to initial state returned to baseline when flow rate was returned to 20 ml/min.

Figure 5. Observation in bladder (n=3) with baseline flow set to 20 ml/min. A) Fold change in initial perfusion pressure to steady-state. When flow was decreased below 5 ml/min, there was a significant decrease in the ratio of steady to initial state perfusion pressure compared to baseline. B) Relationship between average perfusion pressure and flow rate. There was an inverse linear correlation between pressure and flow rate; however, this relationship (dependence) changed below 5 ml/min. The ratio of steady to initial state returned to baseline when flow rate was returned to 20 ml/min.

Figure 6. Measurement of tissue pO2 (n=5). A) Fold change in initial tissue pO2 value. Tissue pO2 initially decreased with decreasing flow rate. With return to baseline flow rate, the average tissue pO2 increased but did not return to the baseline value.

CONCLUSIONS

The bladder undergoes periods of relative ischemia during normal filling and these findings suggest that there is a compensatory mechanism (ie autoregulation) whereby, at low flow rates, tissue oxygenation is maintained. Factors that overcome this mechanism such as complete or chronic ischemia may be critical in the progression to detrusor underactivity and thereby highlight the importance of intervention during the early phases of this disease process.