Study Aims & Hypothesis

Urodynamic studies have demonstrated repeat passive filling-emptying results in a reduction of intravesical pressure (\(p_{ves}\)), strain softening. Active voiding reverses strain softening (dynamic elasticity). Passive emptying requires invasive catheter placement. The aim of this study was to determine if strain softening produced by passive filling-emptying is equivalent to strain softening produced by repeated external compression-release in an isolated working pig bladder. Thus, taking an essential step in developing a novel, non-invasive means to reduce intravesical filling phase pressure.

Results

Bladders undergoing compression-release showed a similar decrease in intravesical pressure compared to passive filling-emptying, indicating strain softening occurs via isovolumetric compression. Increasing \(P_{ves}\) through both filling and compression results in measureable strain softening. Repeated external bladder compression represents a potential means to lower intravesical pressure via strain softening. This novel, non-invasive technique may represent a potential diagnostic test to identify sub-types of overactive bladder and may treat urinary urgency.

Study Design, Materials & Methods

Porcine bladders after slaughter were perfused and maintained at physiologic temperature using a previously designed ex vivo functional model. The effect of passive filling-emptying was compared to compression-release protocol. 1 - passive fill-empty: The bladder was filled to 250 ml and allowed 5 minutes to reach equilibrium pressure (\(P_{1f}\)). An equilibration period was allowed after each step. Intravesical volume was increased to 500 ml to measure peak pressure (\(P_{ref}\)). Next, it was passively emptied via syringe aspiration to 250 ml and intravesical pressure was noted (\(P_{2f}\)). Active voiding was induced with a potassium enriched solution to reset strain softening.

2 - compression-release: The bladder was filled to 250 ml and pressure was allowed to equilibrate (\(P_{1c}\)). The bladder was isovolumetrically compressed to \(P_{ref}\) (part 1) by applying external pressure for 15s and releasing for 15s for 5 cycles. The peak pressure during compression (\(P_{cmax}\)) and the 5 minute equilibrium pressure after release (\(P_{2c}\)) were noted. The protocol was repeated for two cycles. \(P_{1f}\) and \(P_{2f}\) were compared to \(P_{1c}\) and \(P_{2c}\) respectively, and \(P_{1f}\) and \(P_{1c}\) were compared.

Figure 1: Average pressure values (n = 10) for part 1 (A) and part 2 (B).

Figure 2: A similar degree of strain softening was induced. * Indicates a significant difference from initial pressure

Ten bladders were studied. Strain softening was present during passive filling-emptying phases (\(P_{2f} < P_{1f}\), t-test, \(p < 0.05\)) [Fig. 1A] as well as during isovolumetric compression with external pressure (\(P_{2c} < P_{1c}\), t-test, \(p < 0.05\) ) [Fig. 1B], suggesting that significant strain softening had occurred. The pressures after passive filling-emptying and compression-release were not statistically different (\(P_{2cf}\) vs \(P_{2f}\), t-test, \(p > 0.05\)) [Fig. 2], suggesting a similar degree of strain softening was induced by each method.

Interpretation Of Results & Conclusion

Bladders undergoing compression-release showed a similar decrease in intravesical pressure compared to passive filling-emptying, indicating strain softening occurs via isovolumetric compression. Increasing \(P_{ves}\) through both filling and compression results in measureable strain softening. Repeated external bladder compression represents a potential means to lower intravesical pressure via strain softening. This novel, non-invasive technique may represent a potential diagnostic test to identify sub-types of overactive bladder and may treat urinary urgency.