BIOMECHANICS OF PELVIC FLOOR DISORDERS

Margot S. Damaser, Ph.D.

Associate Professor, Dept of Biomedical Engineering,

Cleveland Clinic Lerner College of Medicine, Cleveland, OH; email: damasem@ccf.org

Up to half the women in the U.S. experience pelvic floor disorders during their lifetimes. This set of conditions includes stress urinary incontinence, the unwanted leakage of urine with coughing or laughing; as well as fecal incontinence, the unwanted leakage of stool; and pelvic organ prolapse, in which the pelvic organs fall out of position and can protrude from the body. Although not life threatening, these conditions greatly reduce quality of life. They are strongly correlated with vaginal delivery of children but often don't appear until years later, suggesting inadequate healing process after injury. However, the mechanism of maternal biomechanical injuries incurred during delivery, as well as the healing processes afterward are not well understood.

Since both childbirth and incontinence are biomechanical processes, we have embarked on a study of the mechanisms of injury and disease to better understand how to treat the injuries of childbirth to prevent pelvic floor disorders. The nerve, muscle, and connective tissues responsible for maintaining continence are located in the pelvic region, where the baby's head compresses all nearby maternal tissues during the 2^{nd} stage of labor. This damage occurs as a direct result of the large ratio of baby's head to birth canal in humans: the evolutionary trade-off between the large brain of human babies and bipedalism, which decreases pelvis size. No other animal has a baby's head to birth canal anywhere close to that of humans. Pressure to the vaginal sidewall reaches 240 cm H_2O during the peak of contractions, which is sufficient to cause microcirculatory ischemia to muscle and nerve tissue if maintained for 30 minutes.

Early investigations of the biomechanics of childbirth involved anatomical measurements and x-ray images during delivery. However, these are no longer done due to ethical considerations. Therefore, several mathematical models of childbirth have been developed to investigate the biomechanics and traumatic injuries of delivery. These, along with both clinical and experimental data, suggest that the pudendal nerve is particularly vulnerable to stretch and crush injuries during childbirth. This nerve innervates the external urethral sphincter, the striated muscle primarily responsible for urinary continence, which can also be injured during childbirth via ischemia or compression. Therefore, childbirth represents an unusual injury paradigm in which both a nerve and the muscle it innervates are injured simultaneously.

Over the past 10 years, several animal models have been developed to simulate the maternal injuries of childbirth and investigate the mechanisms of pelvic floor disorder development. Among other things, these have demonstrated that recovery is slowed when both a nerve and the muscle it innervates are injured simultaneously, which may explain why incontinence occurs after delivery. They also suggest that insufficient recovery of elastin after delivery may play an important role in pelvic organ prolapse development.

In this talk I will review the history of the understanding of the biomechanics of childbirth and will relate it to the maternal injuries of childbirth. I will review the results of investigations with animal models of simulated delivery and will describe a biomechanical model of stress urinary incontinence. I will conclude by proposing mechanisms by which birth injury can lead to incontinence and pelvic floor disorders, which suggest potential treatment and prevention paradigms based on the mechanisms of injury & disease.