Biomedical engineers advance on 'smart bladder pacemaker'

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Duke University biomedical engineering researchers have moved a step closer to a "smart bladder pacemaker" that might one day restore bladder control in patients with spinal cord injury or neurological disease.

The team's latest findings show that a device that taps into the urinary "circuit" in the spinal cord could selectively coordinate the contraction and release of muscles required for maintaining continence.

Warren Grill of Duke's Pratt School of Engineering and his colleagues have shown in cats that electrical stimulation can engage the spinal circuitry to effectively empty the bladder, while delivery of lower frequency pulses to the same nerve can significantly increase bladder capacity and improve continence.

In fact, manipulating the nervous system provides a more flexible way of influencing urinary function than would direct bladder stimulation, Grill said.

"Stimulating the bladder directly can cause it only to contract, not to keep it from contracting," Grill said. "We stimulate the sensory inputs in the spinal cord to orchestrate either the inhibition or activation of urination.

"This illustrates an important principle: we can use the 'smarts' of the nervous system to orchestrate control of complex functions," he said.

A similar approach might also have potential for stimulating the spinal reflexes that control locomotion, Grill added. Other investigators are testing such a system for use in physical therapy for people suffering from some form of paralysis, to help them learn to walk again.

Grill presented the team's findings on Friday, Feb. 16, at the annual meeting of the American Association for the Advancement of Science in San Francisco. His presentation was part of a symposium organized through the National Academies' Keck Futures Initiative. The research was supported by the National Institutes of Health and the Paralyzed Veterans of America Spinal Cord Research Foundation.

Individuals with severe spinal cord injuries generally cannot empty their bladders voluntarily, Grill said. Spinal cord injuries also can cause the bladder to become involuntarily overactive, contracting at low volume for ineffective release of urine.

Ineffective emptying of the bladder can lead to complications, including damage to the bladder and frequent urinary tract infections, he said. Therefore, most people with spinal cord injuries are fitted with catheters that carry away urine.

The Duke researchers recently showed in cats that intermittent stimulation of the pelvic nerve that controls the urinary spinal circuitry emptied 65 percent of the bladder volume. The electrical pulses were delivered at a high frequency, mimicking the normal rate of sensory nerve impulses.

"We knew that the sensory fibers that excite the bladder normally fire at a rate of 30 to 40 impulses per second," Grill said. "We used the same rate to trick the circuit to turn on."

In another study, the researchers investigated the use of lower frequency electrical pulses for blocking unwanted bladder contractions. Earlier studies found that continuous low-frequency pulses of the pelvic nerve can suppress involuntary bladder contractions to maintain continence and increase bladder volume by 60 to 110 percent.

However, Grill suspected that the method could be made even more successful by making it more selective, delivering inhibitory pulses only in response to bladder contractions rather than constantly.

"The sensory system is designed to ignore signals if they are delivered constantly," Grill said. An everyday example of this "habituation" effect is the way people become accustomed to the pressure of a watch against the skin and no longer feel it, he said.

Indeed, the researchers found that inhibiting the urinary circuit only when contractions were detected increased bladder capacity by another 15 percent over continuous stimulation.

The researchers monitored bladder contractions indirectly by recording electrical nerve impulses, a sensing method that could be readily incorporated into a device resembling a pacemaker, Grill said.

"We relied on electrical recording of nerve activity that is coincident with bladder contraction to deliver a conditional inhibitory stimulus," Grill said. "It's a fully bioelectric and practical way to improve urinary continence."

The team now is working with Duke University Medical Center researchers on a clinical feasibility study to examine the urinary reflexes of human patients with spinal cord injuries.

Source: Duke University