Implantable Bladder Sensors: A Methodological Review

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The loss of urinary bladder control/sensation, also known as urinary incontinence (UI), is a common clinical problem in autistic children, diabetics, and the elderly. UI not only causes discomfort for patients but may also lead to kidney failure, infections, and even death. The increase of bladder urine volume/pressure above normal ranges without sensation of UI patients necessitates the need for bladder sensors. Currently, a catheter-based sensor is introduced directly through the urethra into the bladder to measure pressure variations. Unfortunately, this method is inaccurate because measurement is affected by disturbances in catheter lines as well as delays in response time owing to the inertia of urine inside the bladder. Moreover, this technique can cause infection during prolonged use; hence, it is only suitable for short-term measurement. Development of discrete wireless implantable sensors to measure bladder volume/pressure would allow for long-term monitoring within the bladder, while maintaining the patient's quality of life. With the recent advances in microfabrication, the size of implantable bladder sensors has been significantly reduced. However, microfabricated sensors face hostility from the bladder environment and require surgical intervention for implantation inside the bladder. Here, we explore the various types of implantable bladder sensors and current efforts to solve issues like hermeticity, biocompatibility, drift, telemetry, power, and compatibility issues with popular imaging tools such as computed tomography and magnetic resonance imaging. We also discuss some possible improvements/emerging trends in the design of an implantable bladder sensor.

Keywords: Urinary Incontinence; Implantable Bladder Sensor; Hermetic; Biocompatible Materials; Telemetry

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INTRODUCTION

Urinary incontinence (UI) is not only caused by peripheral nerve/spinal cord injury but also other factors such as excessive alcohol intake, pregnancy, childbirth, bladder tumor/cancer, and an enlarged prostate. As a result, every individual is at risk for urinary incontinence. In the United States alone, the estimated total national cost of UI in 2007 was $65.9 billion, with projected costs of $76.2 billion in 2015 and $82.6 billion in 2020 [1]. Additionally, according to the World Health Organization, roughly 20 million people are affected by UI annually, worldwide [2].

Over the years, measurement of abnormal bladder urine volume/pressure has been the key to restoring bladder function, creating awareness of when to empty the bladder, as well as improving the quality of life of patients with UI. In a clinical setting, it is common to see patients with UI carrying catheter-based bladder urine sensors around. Even though this method grants the accuracy needed for monitoring urine volume/pressure, it is...