Continuous Hemodynamics Monitor: Novel Smart Sensor for Real-Time Postoperative Cardiac Care

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Importance: Decompensated heart failure causes 3 million rehospitalizations. This is a result of current ineffective and inaccessible cardiac monitoring standards, which rely on symptoms that appear too late in disease progression. Design: This investigation developed an implantable arterial sensor for presymptomatic diagnoses. The sensors were designed and optimized through electromagnetic simulations. The final stretchable prototype was nanofabricated and validated through biomechanical and sensing assays. Additionally, a nitinol actuation system was developed and wirelessly powered to create telemetrically adaptable medical devices. Results: The sensor accurately monitored arterial pressure, flow, and diameter similar to clinical standards with <2% error, as shown by statistically insignificant differences (one-way ANOVA, $p>0.05$). Changes in tissue size and dielectric resulted in proportional changes in the sensor's capacitance reading. The sensors were highly sensitive to pressure changes (0-10 kPa) at 13.46 kPa^-1. Hysteresis was minimized to 2.5%. The novel device's actuation was validated on simulated heart failure hemodynamics. The microcontroller's rechargeable battery was wirelessly charged with power transfer efficiency peaking at 70%. Application: Overall, the novel sensors developed in this project are a viable monitoring system and can be broadly applied to diagnose and monitor decompensated heart failure, heart attacks, and strokes.

Awards Won:

Third Award of $1,000