Wireless and Battery-less Surveillance System of Blood Flow in Textile-based Vascular Grafts

Xiaoqi Tang[1], Martin W. King[1,2],
[1] Wilson College of Textiles, North Carolina State University, Raleigh, NC
[2]College of Textiles, Donghua University, Shanghai, China

Statement of Purpose: Cardiovascular disease is one of the leading causes of death globally. Many of these situations are closely related to plaque buildup on the vessel wall, called atherosclerosis. Using a vascular graft to reopen the narrowed section or bypass the stenosed vessel is a popular therapeutic option. However, even if patients are followed up regularly, critical situations may occur between sequential checkups. Complications such as pain, limb swelling, strokes and/or heart attacks may compromise the patient's health or even threaten the patient's life.

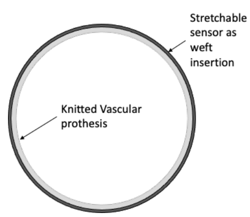
To address this issue, a dynamic surveillance system, capable of continuous monitoring, is necessary. In most surveillance systems proposed by researchers for vascular grafts, measurement of blood flow is the main criteria in the design. As stenosis occurs, the amount of blood passing through a unit length, compared with the original flow rate, can reflect the percentage of flow reduction and the extent of severity of the stenosis.

Currently, mainstream models utilize diffraction-grating transducers, electromagnetic rings, and/or piezoelectric pressure sensors. However, even with advanced flexible materials, these add-on devices either compromise the mechanical performance of the vascular graft or limit the compliance of these implants. As a result, we are proposing in this study a wireless model for blood flow measurement which is completely incorporated into the textile-based vascular graft.

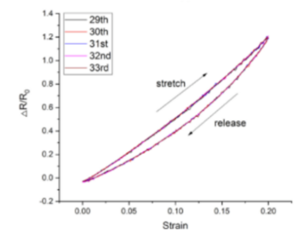
Methods: The blood flow sensor is made of stretchable conductive yarns, such as carbon and silver yarn, which will be twisted or wrapped with polyethylene terephthalate filaments. Then, the stretchable sensor will be integrated inside a knitted polyethylene terephthalate vascular graft using a weft insertion technique, with minimum tension applied. Subsequently, battery-assisted passive radio frequency identification (RFID) technology will also be applied, providing low-frequency wireless transmission protocols. The RFID tag can be activated when the external RFID reader is in range. In addition, RFID tags can identify basic patient information and read data measured by sensors in the body for patient self-monitoring.

An *in vitro* evaluation of the vascular prosthesis implanted phantom vessel will be assembled to verify the effect of the built stretch sensor. Controlled blood flow will replicate normal to extreme blood flow scenarios.

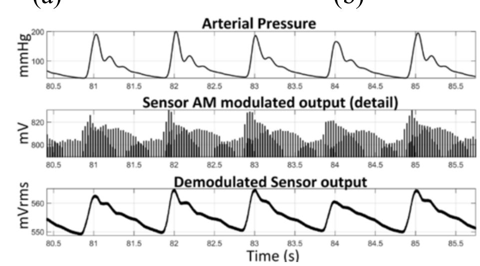
Result: As various volumes of blood pass due to each heartbeat, the stretched and relaxed state of the conductive yarn can convert the displacement into the amount of change in the electrical current. A linear relationship of current or resistance change will be plotted for blood volume detection from the diastolic to the systolic pressure range. The lower and upper limits of unit volume will be set as warning levels.



(a)



(b)[1]



(c)[2]

Figure 1. (a) The cross-sectional view of a stretched sensor within a knitted vascular prosthesis. (b) A linear relationship between the sensor resistance which corresponds to strain (c) Flow rate vs. time to monitor blood flow.

A flow rate vs. time chart will be generated. In an ideal situation, the cyclic flow rate of blood is recorded and reflected in real-time. The signal of each cycle shows minimum drifting or distortion.

References:

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