Ambulatory Device for Urinary Incontinence Detection in Female Athletes

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Urinary incontinence (UI) has been known as a prevalent concern among parous and elderly women. However, recent studies have shown an unexpectedly high occurrence of UI in young physically fit female athletes who are actively participating in vigorous physical activities. Those study results motivated us to explore the relationship between daily intensive exercise and the occurrence of UI. As the first step to advance our understanding of this problem, an ambulatory device was developed for recording urological response to the intense force levels to which female athletes are subjected. The device consists of three types of wearable sensors, including 1) a +/– 25g tri-axial accelerometer, 2) a 360° biaxial inclinometer and 3) a urinary leakage detector or ULD. It also contains a compact data logger for real-time data recording with high frequency and precision (125 Hz, 16-bit A/D converter). The accelerometer and inclinometer help to determine the force levels developed in the body during physical activities at which urinary leakage occurs. Two types of ULD sensors have been designed: (1) copper lattice ULD, and (2) thermistor array ULD. Copper lattice ULD senses the UI based on the fact that urine drops reduce the resistance of the copper lattice resulting in a voltage change. The thermistor array ULD makes use of the finding that leaked urine is warmer than the surface of the skin, such that the integrated thermal components respond to urine leakage differently. In addition, a thermoelectric cooler is applied to produce a constant reference temperature. The entire device is small, lightweight, nonintrusive, and can be worn comfortably by subjects on their wrists or low back for at least 3 hours of continuous data recording. The test results from the recruited female athletes show that the three sensors can simultaneously record the intensity of activity and the corresponding urine leakage. However, for the copper lattice ULD, substantial sweat developed during the vigorous activity which produced an artifact and prevented the device from detecting the occurrence of urine leakage. The recently designed thermistor array ULD is less sensitive to sweat, resulting a more reliable sensor than is provided by the copper lattice ULD. The wearable sensor based device enables us to determine if urinary incontinence in female athletes occurs during vigorous physical activities or as a result of the fatigue caused by these activities. This conclusion facilitates the understanding of the mechanism of UI and assists trainers and coaches with the design of an appropriate training program that reduces the occurrence of UI in these female athletes.

Numerical Study of Shear-Induced Thrombus Formation Over Aterial Stent Struts

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Thrombosis remains an important problem in both bare-metal and drug eluting stents. Platelet accumulation appears to be highly shear dependent in uniform parallel plate and stenosis models. This study was performed to evaluate thrombus formation location and size with respect to time for a stent. A three-dimensional laminar flow field was modeled via computational fluid dynamics through a stent-containing coronary sized vessel. Platelet deposition and accumulation was then simulated using a shear dependent accumulation function. The platelet deposition rate is given by the function: $3.2\dot{\gamma}+67$ platelets/mm^2/s, where $\dot{\gamma}$ is the shear rate, which comes from a linear regression to data presented in Ku and Flannery 2007. A three-dimensional stent with a helical strut matrix design and a pitch of 21 mm was designed around a 3 mm diameter vessel. Square strut designs of 0.15 mm × 0.15 mm and 0.30 mm × 0.30 mm were considered, with each strut embedded halfway into the vessel. A 30° section of the stent was modeled because of stent symmetry. The inlet was set at a mean Reynolds number of 200 by specifying a pressure differential across the length of the vessel. Thrombus growth based on shear rate was set through the equation: $d\Phi/dt=(3.2\dot{\gamma}+67)(V_{\text{platelet}}/V)\Sigma_{n=0}^{M}A_n$. V is volume, Φ is the volume fraction of thrombus, M is the number of surrounding faces that are either a wall face or are neighboring a computational cell denoted as occluded by thrombus, associated with area, A. Each term without a subscript pertains to the local computational cell prescribed as undergoing thrombus growth. Thrombus cell occlusion was assumed to occur when thrombus filled 80% of the cell's volume. Maximum shear rates occur near the edges along the inner blood surface side of the stent struts. Thrombus growth increases more in the axial direction of the stent relative to the radial direction for the larger strut size. Conversely, the thrombus growth is more uniform in all directions along the smaller struts. The difference emanates from the two distinctly localized high shear contours near the edges of the larger stent struts, while the high shear regions were less distinct for the smaller strut size. Quadrupling the cross sectional area of a strut increases the initial maximum shear rate along the strut by 50%, in addition to doubling the available surface area for platelet deposition. Therefore, increasing strut size has a threefold effect on platelet deposition rate, leading to faster vessel occlusion. This computational technique may be extended to approximate where thrombus may grow to completely occlude a blood vessel and the length of time occlusion would take. The CFD modeling technique may also be used to evaluate thrombus deposition on medical devices such as heart valves and ventricular assist devices.