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CORRELATION BETWEEN LVAD PUMP SPEED, HIGH FLOW, LOW PI AND COGNITIVE DECLINE

Every heartbeat creates a small pressure pulse that travels to the brain, causing blood vessels, brain tissue, and cerebrospinal fluid to expand and contract in sync with your pulse. Low pulsatility often signals diminished flow variation and possible microvascular or regulatory dysfunction.

A left ventricular assist device (LVAD) is a mechanical pump that supports the left ventricle by moving blood from the ventricle to the aorta, thereby maintaining systemic circulation in patients with advanced heart failure. Unlike HeartWare (HVAD) and HeartMate II LVAD, the HeartMate 3 features pre-programmed intrinsic pulsatility. Evey two seconds, the pump rapidly slows down and speeds up. This speed modulation creates an artificial pulse designed to move blood out of the heart's chambers, reducing the risk of blood clots and strokes. Even with this technology, the pulse is often low-fidelity, and patients may still lack a traditional, easily felt pulse.

Blood flow to the brain can continue without a traditional rhythmic pulse through continuous, non-pulsatile perfusion. Continuous flow devices or mechanical circulatory support, such as certain ventricular assist devices (VADs) can deliver a steady, continuous stream of blood rather than beating waves. Prolonged absence of normal pulsatile flow in everyday circulation can be linked to stress or increased risk of ischemia if blood delivery drops below metabolic needs.

The pump speed of a left ventricular assist device (LVAD) refers to the rate at which the internal rotor spins, measured in revolutions per minute (RPM). The speed directly influences blood flow through the pump, which is estimated in liters per minute (L/min) and reflects the cardiac output provided by the device. Higher speeds can reduce PI by increasing continuous flow dominance.

Flow in an LVAD is not directly measured but is estimated based on pump speed (rpm), power consumption, and blood viscosity. LVAD flow refers to the blood flow generated by a

left ventricular assist device, typically measured in liters per minute, and is influenced by pump speed, preload, and afterload. Preload, the adequate venous return is necessary for optimal LVAD flow. Low preload (e.g., hypovolemia) reduces flow, while high preload increases it. Afterload, or systemic vascular resistance affects flow; high afterload can reduce LVAD output, while low afterload may increase it.

The Pulsatility Index (PI) is a key LVAD parameter that reflects the variation in flow through the pump during the cardiac cycle, providing insight into native left ventricular function and preload status. The Pulsatility Index (PI) is a numerical value displayed on LVAD controllers, representing the degree of flow pulsatility generated by the patient's native heart in combination with the continuous-flow pump. It is calculated based on the difference between maximum and minimum pump flow over a cardiac cycle, normalized to the average flow. A higher PI indicates greater native ventricular contribution to pulsatile flow, while a lower PI suggests reduced left ventricular filling or increased pump dominance. Reduced pulsatility can limit cerebral perfusion reserve during stress or hypoxia, contribute to cognitive decline via microvascular impairment, and serve as a biomarker for vascular health and cerebrovascular reactivity.

Medical technology companies are developing next-generation devices designed to accurately mimic a natural heartbeat without using traditional spinning blades. CorWave LVAS device uses an innovative undulating membrane technology inspired by swimming motion of marine animals. Instead of a spinning impeller, a membrane moves up and down to propel blood. In clinical investigations, CorWave has demonstrated the ability to recreate the filling and ejecting phases of a natural heart, generating a clear, palpable pulse. TORVAD (Toroidal Ventricular Assist Device) utilizes a unique design with two independently controlled pistons. It is specifically engineered to generate low-shear, high pulsatile flow that closely mimics the native cardiac cycle.