Welcome to Volume 1, Issue 15 of *Alternativz*. This is the 3rd issue in the series ***Breathing & The Brain***. Referring to Issue 14, at the end of my talk at ISNR, I offered that I anticipate that we will find that the diaphragm plays a particularly vital role in the circulation of blood in erect vertebrates.

During the Q & A following the talk I went on to say that horizontal and vertical vertebrates all have a heart, but not all have a diaphragm, the appearance and sophistication of the diaphragm appearing to have followed the evolutionary "erectness" of species.

Per my hypothesis, the diaphragm is necessary to move blood upward against gravity, which for water exerts 1 mmHg of gravitational or hydrostatic pressure for each 13.6 mm (~.5 inch) of distance from the surface. In the case of the human body "the surface" can be considered to be the level of the heart.

While standing still, gravitational pressure exerted on the blood results in arterial pressure in the feet of ~90mmHg more than at the level of the heart, i.e. ~190mmHg. Corresponding venous pressure in the feet, ~90mmHg, is absent the pressure exerted by the heart and is almost all due to downward gravitational pressure exerted on blood in the venous tree.

Above the level of the chest, gravitational pressure works against pressure exerted by the heart into the ascending aorta and carotid arteries, pressure falling off by ~20mmHg from 100mmHg to ~80mmHg.

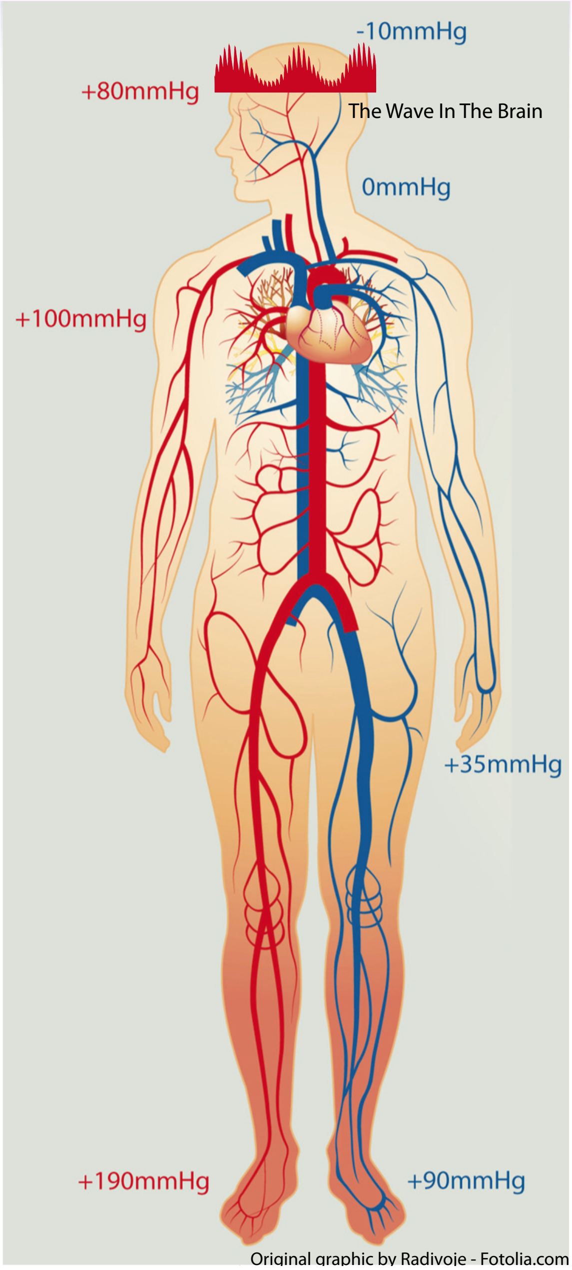

Figure 1: Pressures In Arterial And Venous Systems When Erect Due To Gravitational Affects

Note that these pressures, from *Medical Physiology*, are "normal" and do not represent those of slow, deep, rythmic breathing, which per my conservative estimate, can add an 20-30mmHg of pressure to the picture, but in both directions. For example, where regular breathing may yield a resting blood pressure of 120/80, a difference of 40mmHg between static cardiac systole and diastole, the pressure resulting from slow, deep, rythmic breathing might result in blood pressure of 115/55, the difference between the dynamic systole and diastole being 60mmHg. It is theorized that there a couple of reasons for this change:

1) Blood flow increases because the differential pressure in the systemic circulation increases. This is a consequence of the diaphragm moving up and down more fully, and

2) Average work performed by the heart decreases because the diaphragm is contributing strongly to pressure generation and resultant blood flow. Baroreceptors detect this increase in flow and pressure caused by breathing and the autonomic nervous system asserts vagal action, modulating the action of the heart, both rate and contractile strength, the diaphragm accepting a significant portion of the

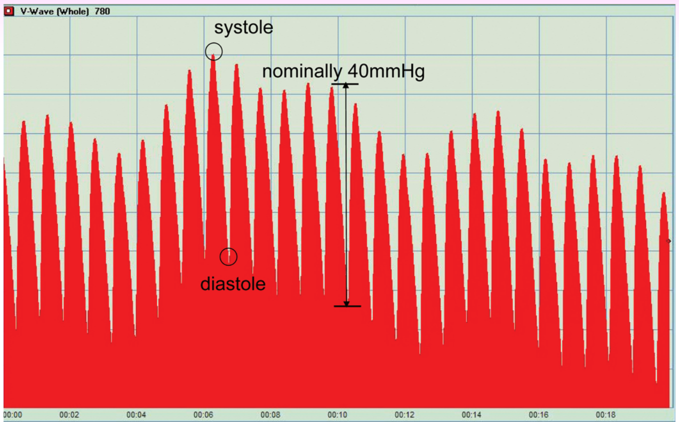

Figure 2: Shallow respiration where the heart beat demonstrates ~40mmHg between static systole and diastole.

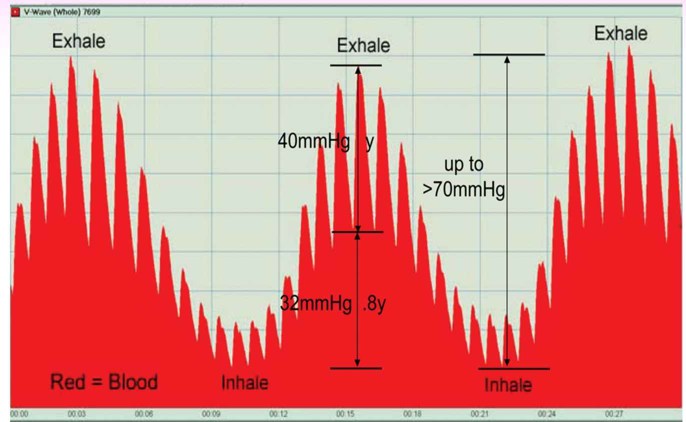

Figure 3: Coherent Breathing where dynamic systole and diastole demonstrate 60+mmHg of difference.

cirulatory burden, especially that of venous return where the heart must work extra hard to generate negative pressure in the absence of significant downward movement of the diaphragm, i.e. inhalation.

The central idea here is that the heart easily facilitates circulation when a body, including ours, is horizontal and the effects of gravity on the circulation are normalized. For humans, shavasana is probably the position wherein this occurs optimally. But when we are erect the heart needs help - for optimal circulatory outcome.

It is accepted that the autonomic nervous system recognizes body position and adjusts heart rate variability (HRV) accordingly - when we are horizontal, even when we are breathing coherently, HRV diminishes. The reason for this is that we normalize the gravitational effects on blood, blood distributing itself more evenly throughout the body. Blood pressure differential throughout the body is also normalized. We see a drop in the amplitude of the Valsalva Wave, simply because blood volume is normalized. Changes in flow and pressure being the impetus for breathing induced heart rate variability (HRV), it also diminishes in amplitude. Where HRV may be 25 beats in a seated position, it may drop to 8 beats or even less when horizontal.

All mammals possess diaphragms, but power and sophistication appear to correlate with erectness. Its interesting to note that 2-leggedness, i.e. rising off of one's hind limbs to stand or walk requires erectness. Erectness presents a special problem relative to gravitational affects on circulation and undoubtedly required evolutionary adaptation. Without a diaphragm, standing on hind legs may have been risky, resulting in dizziness and fainting, both life threatening in the wild.

A fish is possibly a best example, where fish live in what is generally a low gravitational environment due to their aqueous surroundings. Fish have hearts but as a rule don't have lungs or diaphragms. Snakes have lungs but no diaphragms - employing the musculature of their rib cage to generate changes in thoracic pressure. Turtles use "axial" muscles, lizards have proto-diaphragms, early constructs that perform the function of a diaphragm. Humans have relatively large powerful diaphragms, although, unless we breathe deeply or are physically active, we tend not to use much of our diaphragm capacity. Where we have ~10 cm of diaphragm range, most of us use 1-2 cm to breathe with. For this reason, for most of the time, the Valsalva Wave looks like Figure 2, where the heartbeat is the predominant feature. When we breathe "coherently" it looks more like Figure 3, where the respiratory wave underlying the heartbeat is the predominant feature.

Initial indications are that when the brain receives this Valsalva Wave, it generates electrical impulses that are very large, maybe 10 times the amplitude of normal brainwaves. This stands to reason, as the brain functions of the basis of glucose and oxygen - delivered by the blood.

Thank you for your interest, Stephen Elliott, President, COHERENCE LLC

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