Evaluating the Logical Relationships of Reflected Wave Transit Time with the Complex Global Reflection Coefficient, Height, and Pulse Wave Velocity

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Background: Reflected wave transit time (RWTT) represents the time at which arterial wave reflections begin to exert significant effects on aortic pressure and flow. Different methods exist to compute RWTT, each yielding conflicting interpretations regarding underlying cardiovascular changes. RWTT should sensibly correlate with body height and pulse wave velocity (PWV). Furthermore, RWTT should correlate strongly with the phase of the complex global reflection coefficient ($\Gamma_{\phi,1}$), as this variable describes the time lag between backward and forward waves in the frequency-domain. We evaluated the relationship between RWTT measured with 3 methods and the following 3 variables: height, PWV and $\Gamma_{\phi,1}$, to determine the method that is most logically consistent.

Methods: Central pressure and flow waveforms were measured noninvasively using carotid tonometry and PC-MRI, respectively, in 201 subjects (mean age = 61 years; range 26 to 93), along with carotid-femoral PWV (cfPWV). RWTT was computed using (1) wave separation analysis ($RWTT_{WSA}$); (2) inflection point on pressure waveform ($RWTT_{INF}$); (3) tube-load modeling ($RWTT_{TUBE}$).

Results: $RWTT_{WSA}$ did not show significant relationships with either height (standardized β=0.14; P=0.08) or CF-PWV (standardized β=-0.006; P=0.94). $RWTT_{INF}$ was significantly related only to cfPWV (β=-0.15; P=0.01). In contrast, $RWTT_{TUBE}$ was strongly related to $\Gamma_{\phi,1}$ (β=-0.724; P<0.001) and was significantly related to body height (β=0.29; P<0.0001), and cfPWV (β=-0.28; P<0.001).

Conclusions: $RWTT_{WSA}$ and $RWTT_{INF}$ demonstrated inconsistent relationships with $\Gamma_{\phi,1}$, despite their presumed relation to backward wave timing. Only $RWTT_{TUBE}$ demonstrated the logically expected relationships with $\Gamma_{\phi,1}$, height, and PWV. Closer inspection of the putative methods ($RWTT_{WSA}$, $RWTT_{INF}$) reveals that both equate the time around peak flow to reflection timing. This imposes an artificial restriction on RWTT. $RWTT_{TUBE}$ does not have such artificial constraints, uses information contained in entire pressure and flow waveforms, and produce values that have consistent and logical trends with $\Gamma_{\phi,1}$, height, and PWV.