An In-silico Study of Sex Differences in Carotid Hemodynamic Waveforms

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Background: In recent years, there has been growing awareness of sex differences in cardiovascular (CV) physiology, and sex is now recognized as a crucial variable for accurately diagnosing CV disease. Moreover, CV aging progresses differently in males and females, with females experiencing a steeper increase in arterial stiffness after menopause. Carotid hemodynamic waveforms are often monitored to assess CV health (e.g., arterial stiffness, cardiac function); however, their morphology differs between the sexes (e.g., females exhibit lower velocity waveform pulsatility, and higher velocity and pressure systolic augmentation). As such, a deeper understanding of how carotid waveforms are affected by CV sex differences at different ages is required for improved clinical monitoring. This may be studied in-silico via one-dimensional (1D) hemodynamic modeling. **Methods:** Starting from a validated 55-branch 1D model, CV parameters including cardiac output, arterial diameters, lengths, and compliances were adapted according to literature population data, to obtain average healthy male and female virtual subjects at the 3rd and 6th age decades. Simulated carotid waveform features were compared among the sexes in both the young and elder subjects. The 1D blood flow equations with an elastic tube law were solved using the NEKTAR++ Pulse Wave Solver. **Results:** The simulated female carotid velocity waveform exhibited lower pulsatility (amplitude of first systolic peak) and higher augmentation (amplitude of second systolic peak relative to first) compared to its male counterpart. Female carotid pressure augmentation was also higher, and its rate of change with age was greater in females compared to males. These differences are consistent with in-vivo findings. **Conclusions:** The sex-specific models developed reproduce realistic differences in carotid hemodynamics and may be used to investigate the mechanisms of sex-related CV differences.