Influence of the pressure measuring site for Velocity / Pressure Loops and rationale for a Transfer Function

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Background

Velocity/pressure (Vel/P) loops are obtained by combining aortic blood velocity (measured by esophageal Doppler-ED-, CombiQ^{TM}, Deltex Medical, Chichester, UK) and arterial pressure signals. They represent a tool to estimate afterload of the heart and arterial stiffness with at least two remarkable angles: β and γ. Pressure is usually measured in the radial artery (P_{Rad}) rather than in the descending thoracic aorta (P_{AoDesc}) where ED measures blood flow. Our aims were to assess the influence of the site of pressure recording on the values of β and γ and to develop a mathematical transfer function (TF) to estimate P_{AoDesc} from P_{Rad} and then reconstruct Vel/$P_{TFAoDesc}$ loops.

Material and Methods

After institutional review board approval (CE SRLF n°11-356), 15 patients scheduled for elective endovascular neuroradiology were included. Pressures were recorded simultaneously in the radial artery and in the aorta. Vel/P_{Rad} and Vel/P_{AoDesc} loops were constructed and compared. A transfer function was estimated using an autoregressive-exogenous (ARX) model to obtain a simulated descending thoracic aorta pressure waveform ($P_{TFAoDesc}$). The estimation was quantified by the normalized root mean squared error (NRMSE). Vel/$P_{TFAoDesc}$ loops were constructed and compared to Vel/P_{AoDesc} loops.

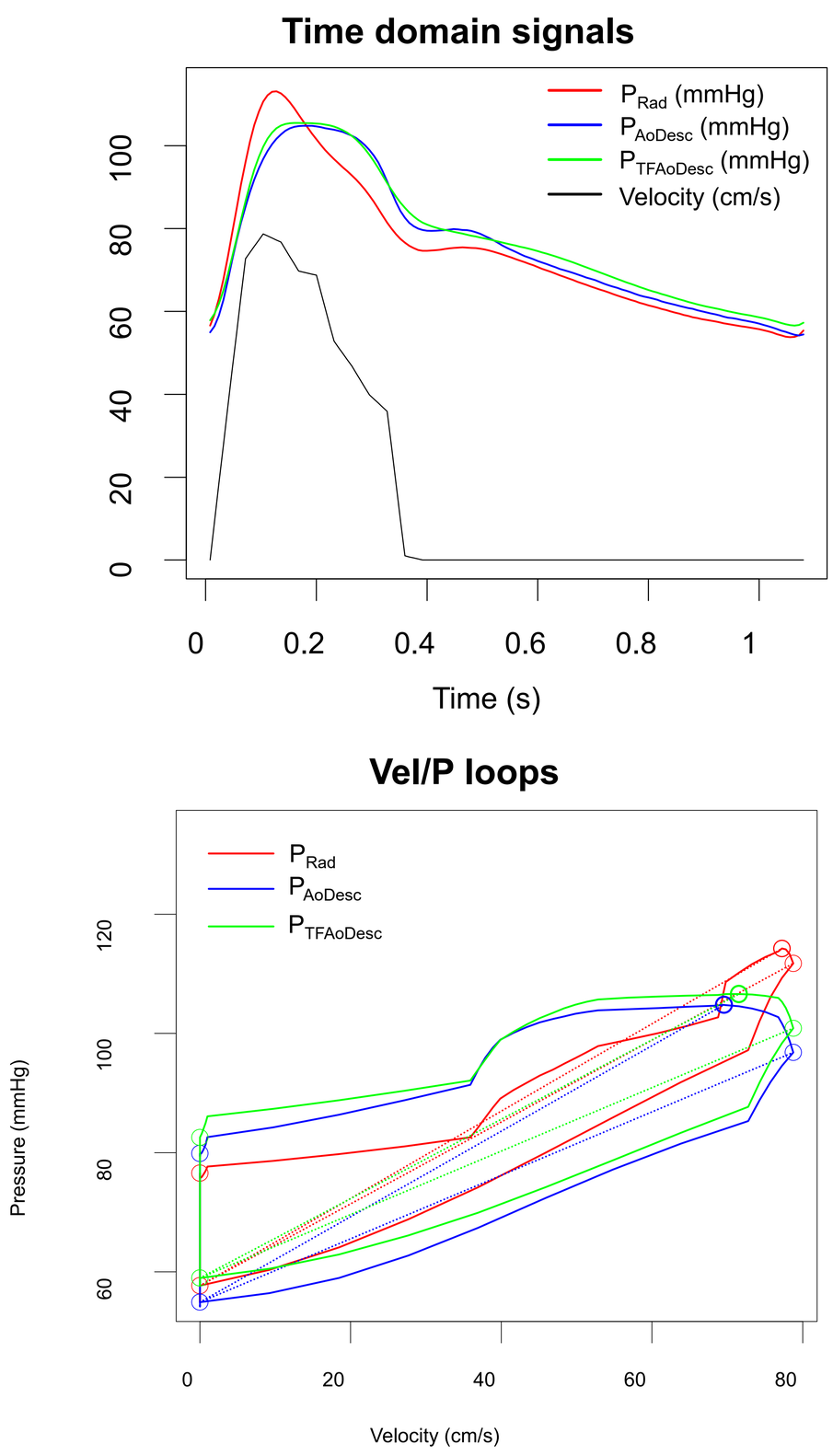

Figure 1: Sample data expressed in the time domain above and in a Vel/P loop below. The blue loop represents measured descending aortic pressure (P_{AoDesc}) and constitutes the reference. Vel/$P_{TFAoDesc}$ is a much more accurate estimation of Vel/P_{AoDesc} than Vel/P_{Rad}.

Results and Discussion

153 loops were analysed. β and γ angles were systematically lower in the Vel/P_{Rad} compared to the Vel/P_{AoDesc} loops (36° [34° - 40°] vs. 43° [38° - 48°] for β, 11° [3°-15°] vs 25° [13°-30°] for γ, $p < 0.0001$). The ARX model simulated $P_{TFAoDesc}$ with a NRMSE of 93% [77 - 96]. β and γ obtained with Vel/P_{AoDesc} and Vel/$P_{TFAoDesc}$ were similar and strongly correlated ($\rho = 0.96$, $p < 0.0001$) (Fig 1&2)

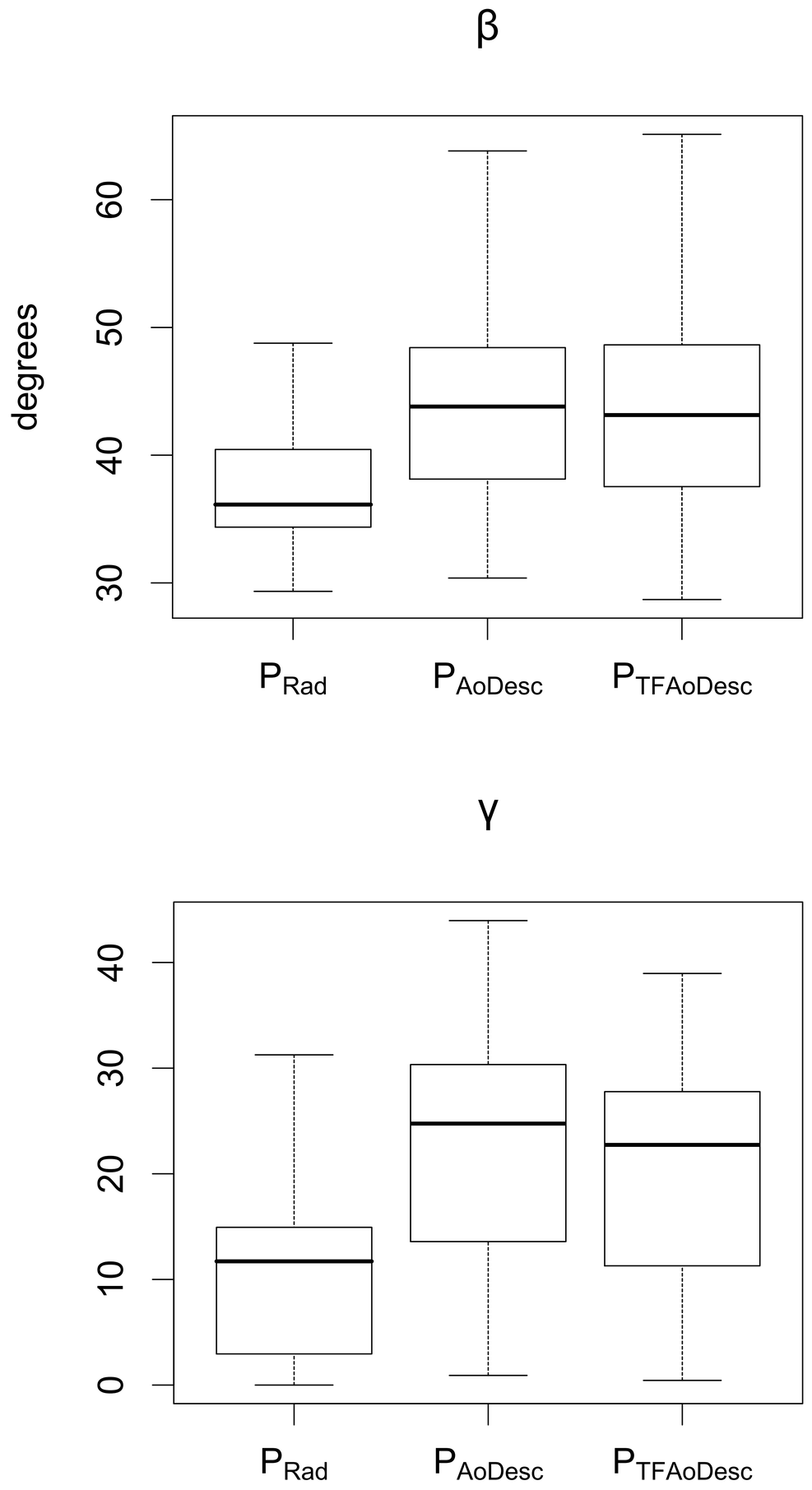

Figure 2: Boxplots for β and γ angles. Vel/P_{Rad} loops systematically underestimate the angles.

Conclusion

The location where the arterial pressure is monitored has a huge influence on the Vel/P loop parameters. Using a transfer function improves the estimation of the pressure waveform at the site of the Doppler signal.