Background

- Cardiovascular disease is the single biggest killer in the world.
- Central aortic pressure is now regarded as the best predictor of cardiovascular event.
- Applanation tonometry is the only technique to estimate aortic pressure throughout the whole cardiac cycle

PROBLEM

- Not accurate for high-frequency components.
- Not patient specific as uses a generalized transfer function.
- Impossible to couple with an imaging modality

CHALLENGE

Derive central pressure waveform from aortic flow velocity

Method

Result

- Part I: Early systole (under the assumption of negligible reflection waves)
  Water Hammer equation
  \( P_a(t) = \rho \cdot PWV \cdot U_a(t) \)
- Part II: Mid systolic peak
  Second-order polynomial approximation
  \( P_a(t) = at^2 + bt + c \)
- Part III (numerical) or III'+III (experimental): Diastole
  Exponential curve with same exponential decay as target pressure
- Part III' (numerical): Dicrotic notch
  Taken from Water Hammer pressure waveform (Part I) and incorporated at the beginning of diastole

Results

Assumed to be known:

- Pulse Wave Velocity (PWV)
- Diastolic Blood Pressure (DBP)
- Mean Arterial Pressure (MAP)
- Diastolic decay (\( t \))

Numerical results for a generically-computed one-artery model:

<table>
<thead>
<tr>
<th>Number of datasets</th>
<th>PWV (m/s)</th>
<th>Compliance C (mm(^2)/Pa)</th>
<th>Waveform</th>
<th>P(_{1})</th>
<th>SBP</th>
<th>P(_{a})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean (mmHg)</td>
<td>MeanSD (mmHg)</td>
<td>Min (mmHg)</td>
</tr>
<tr>
<td>15</td>
<td>3.55</td>
<td>10.16</td>
<td></td>
<td>1.1±0.2</td>
<td>1.7±2.9</td>
<td>5.7</td>
</tr>
<tr>
<td>12</td>
<td>5.02</td>
<td>6.10</td>
<td></td>
<td>0.9±0.1</td>
<td>0.3±1.1</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Experimental results with a dual pressure/Doppler flow transducer (n=18)

Implications

- First derivation of central pressure based on phenomenon occurring directly in the ascending aorta
- Potential to derive left ventricular pressure noninvasively
- Possibility to partition pulsatile component of aortic pressure into:
  - Those arising as a result of aortic stiffening (PWV)
  - Those arising as a result of altered ventricular dynamics (\( U_a \))