Let's Gain More Confidence Of Clinicians With Our Colorful Contours: Blood Flow Simulation In Arteries Using Abaqus & STAR-CCM+

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Clinicians and engineers

How to attract the attention of clinicians to our colorful contours?
Clinicians and engineers

- Time-consuming numerical methods are not interesting for surgeons
PRINCIPIA

- Mechanical and structural problems, particularly those with a dynamic and/or non-linear character: impacts, earthquakes, explosions, vibrations, large deformations, etc.
- The Spanish agent for SIMULIA (from 1988), distributes and supports SIMULIA products, being the program Abaqus among them
- + 30 years of experience
- Experiences in different sectors:
  - Aerospace
  - Automotive
  - Life sciences
  - Civil
  - Defense
  - Naval
  - Nuclear
  - Petroleum
SIMULIA

Dassault Systèmes Brand for Making Realistic Simulation an Integral Business Practice to Explore, Discover, Understand, and Improve Product, Nature, and Life
Idealization

Votta, Herrero, Suo, Bailevs, Kim, Qiao & Liu, Moirean, Huang and Brawn
Cardiovascular Auto-regulation

- Glossopharyngeal Nerve (Cranial Nerve IX)
- Sinus Nerve
- R. Internal Carotid
- L. Internal Carotid
- R. External Carotid
- L. External Carotid
- Carotid Sinus Receptors
- Ascending Aorta
- Aortic Arch Receptors
- Vagus Nerve (Cranial Nerve X)

Graphs showing:
- Resistance (PRU_100)
- Flow (ml/min/100g)
- Pressure (mmHg)

Legend:
- Passive
- Autoregulation
Cardiovascular Auto-regulation

Inlet flow (heart)

Outlet

P1

10%

P2

5%

P3

5%
A+IPBC method
A+IPBC method

- Implicit or Explicit FSI

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Implicit or Explicit FSI
Aortic dissection
Aortic dissection
Aortic dissection
Aortic dissection
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Aortic dissection

<table>
<thead>
<tr>
<th></th>
<th>Iter.1</th>
<th>Iter.2</th>
<th>Iter.3</th>
<th>Iter.4</th>
<th>Iter.5 (1\textsuperscript{st} cycle)</th>
<th>Iter.5 (2\textsuperscript{nd} cycle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta P_1 (Pa)$</td>
<td>0.0</td>
<td>-150.0</td>
<td>-37.16</td>
<td>-31.40</td>
<td>-30.37</td>
<td>-30.37</td>
</tr>
<tr>
<td>$\Delta P_2 (Pa)$</td>
<td>0.0</td>
<td>-10.0</td>
<td>-7.25</td>
<td>-18.95</td>
<td>-1.13</td>
<td>-1.13</td>
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<tr>
<td>$\Delta P_3 (Pa)$</td>
<td>0.0</td>
<td>-10.0</td>
<td>-6.93</td>
<td>-15.12</td>
<td>-0.66</td>
<td>-0.66</td>
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<tr>
<td>$Q_1$ (%)</td>
<td>4.79</td>
<td>25.82</td>
<td>12.03</td>
<td>10.47</td>
<td>11.14</td>
<td>11.99</td>
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<tr>
<td>$Q_2$ (%)</td>
<td>5.37</td>
<td>4.86</td>
<td>5.84</td>
<td>7.75</td>
<td>5.25</td>
<td>5.35</td>
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<tr>
<td>$Q_3$ (%)</td>
<td>5.34</td>
<td>4.85</td>
<td>5.70</td>
<td>7.45</td>
<td>4.67</td>
<td>4.80</td>
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<tr>
<td>$Q_4$ (%)</td>
<td>84.50</td>
<td>64.47</td>
<td>76.43</td>
<td>74.33</td>
<td>78.94</td>
<td>77.86</td>
</tr>
</tbody>
</table>
Aortic dissection

A Patent False Lumen without Thrombus
B False Lumen with Partial Thrombosis
C False Lumen with Complete Thrombosis

BP, 140/70 mm Hg
BP, 140/70 mm Hg
BP, 140/70 mm Hg

140
120
BP, 140/80 mm Hg, MAP, 100 mm Hg
BP, 120/100 mm Hg, MAP, 107 mm Hg
BP, 10/10 mm Hg, MAP, 10 mm Hg

200 mm Hg
200 mm Hg
200 mm Hg

0 mm Hg
0 mm Hg
0 mm Hg

TSAI
Aortic dissection

- Collaborating with Hospital Puerta de Hierro, Madrid
Aortic dissection
Aortic dissection

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  Hospital Puerta de Hierro, Madrid
Aortic dissection

- Collaborating with
  Hospital Puerta de Hierro, Madrid
Aortic dissection

Collaborating with
Hospital Puerta de Hierro, Madrid
Patient-specific model
Patient-specific model
Patient-specific model
Patient-specific model
Conclusions

- Faster numerical simulations
- Reliable results
- Collaboration with hospitals
- New projects collaborating with biomedical industries
Thanks!

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