* **Hybrid ML-mechanics framework**: Novel integration of deep learning with computational solid mechanics for real-time aortic biomechanics prediction.
* **Patient-specific dataset pipeline**: Automated generation methodology incorporating individualised geometries, material properties, and haemodynamic data.
* **Stress-strain surrogate model**: Neural network architecture trained to predict spatial distributions of Second Piola-Kirchhoff stress and Right Cauchy-Green strain tensors across heterogeneous patient anatomies.
* **Clinical translation efficiency**: Demonstrates orders-of-magnitude computational acceleration compared to conventional finite element analysis, enabling point-of-care clinical applicability.