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Physics Informed Deep Residual Networks Based Type-A Aortic Dissection Prediction

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Abstract : Purpose: Acute Type A aortic dissection is a well-known cause of extremely high mortality rate. A highly accurate and cost-effective non-invasive predictor is critically needed so that the patient can be treated at earlier stage. Although various CFD approaches have been tried to establish some prediction frameworks, they are sensitive to uncertainty in both image segmentation and boundary conditions. Tedious pre-processing and demanding calibration procedures requirement further compound the issue, thus hampering their clinical applicability. Using the latest physics informed deep learning methods to establish an accurate and cost-effective predictor framework are amongst the main goals for a better Type A aortic dissection treatment. Methods: Via training a novel physics-informed deep residual network, with non-invasive 4D MRI displacement vectors as inputs, the trained model can cost-effectively calculate all these biomarkers: aortic blood pressure, WSS, and OSI, which are used to predict potential type A aortic dissection to avoid the high mortality events down the road. Results: The proposed deep learning method has been successfully trained and tested with both synthetic 3D aneurysm dataset and a clinical dataset in the aortic dissection context using Google colab environment. In both cases, the model has generated aortic blood pressure, WSS, and OSI results matching the expected patient's health status. Conclusion: The proposed novel physics-informed deep residual network shows great potential to create a cost-effective, non-invasive predictor framework. Additional physics-based de-noising algorithm will be added to make the model more robust to clinical data noises. Further studies will be conducted in collaboration with big institutions such as Cleveland Clinic with more clinical samples to further improve the model's clinical applicability.

Keywords : type-a aortic dissection, deep residual networks, blood flow modeling, data-driven modeling, non-invasive diagnostics, deep learning, artificial intelligence.
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