Title

Prediction of thrombin generation thresholds for coagulation initiation under flow using machine learning surrogate models

Authors

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Abstract

In veins, clotting initiation displays a threshold response to flow intensity and injury size. Mathematical models can provide insights into the patient-specific conditions leading to clot growth initiation under flow. However, it is hard to determine the thrombin generation curves that favor coagulation initiation in a fast manner, especially when considering a wide range of conditions related to flow and injury size. In this work, we propose to address this challenge by using a neural network model trained with the numerical simulations of a validated 2D model for clot formation. Our surrogate model approximates the results of the 2D simulations, reaching an accuracy of 94% on the test dataset. Our study tackles the challenge of identifying the conditions initiating clot growth in veins, influenced by flow intensity and injury size. We employ artificial intelligence, particularly deep neural networks, to streamline the assessment of thrombin generation curves favoring coagulation initiation, even under diverse flow and injury conditions. Various machine learning algorithms were explored, with deep neural networks, support vector machines, and decision trees consistently achieving accuracies exceeding 90%, while higher-level boosting algorithms like XGBoost and CatBoost reaching above 95%. Deep neural networks were preferred due to their proficiency with high-dimensional data, anticipating future research expansions. In summary, our innovative approach utilizing artificial neural networks serves as a proof-of-concept tool for estimating bleeding risk in patients based on their Thrombin Generation Assay results. This promises to enhance our understanding of clot formation under various conditions, revolutionizing clinical assessments and treatments.

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