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522 Enhanced Artificial Intelligence (AI)-Driven Prediction of Vaso-Occlusive Crises in Sickle Cell Disease: Precision through Advanced Machine-Learning Frameworks and Digital Remote Monitoring

Program: Oral and Poster Abstracts
Type: Oral
Session: 900. Health Services and Quality Improvement: Hemoglobinopathies: Navigating and Optimizing Healthcare Systems
Hematology Disease Topics & Pathways:
Research, Sickle Cell Disease, Artificial intelligence (AI), Adult, Translational Research, Hemoglobinopathies, Diseases, Emerging technologies, Technology and Procedures, Study Population, Human, Machine learning

Sunday, December 8, 2024: 10:45 AM

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Background

For individuals with Sickle Cell Disease (SCD), vaso-occlusive crises (VOCs) present a significant ongoing challenge. VOCs, responsible for the majority of SCD hospitalisations, lead to severe organ damage and increased mortality risk, making early detection crucial. Our prior research highlighted the potential for digital health tools and wearable technology to support early VOC detection. This submission updates our predictor model presented at the American Society of Haematology 65th Annual Meeting and Exposition (ASH 2023), incorporating enhancements in our Artificial Intelligence (AI) methodology to improve patient outcomes and quality of life (QoL).

Aims

To advance the curation of an AI model through longitudinal capture of physiological data by a wearable smartwatch, and electronic patient-reported outcomes (ePROs) entered via a specialised mobile app (“digital patient wallet”), enabling the prediction of potential VOC onsets with optimised real-world accuracy.

Methods

Participants provided informed consent for longitudinal data capture and analysis through an FDA-cleared wearable device and a digital patient wallet for daily ePRO entry, including QoL-linked scores and self-reported VOCs. Wearables automatically recorded metrics linked to physical activity, sleep quality, heart rate and sleep blood oxygen. Participants completed a Subject Access Request form enabling medical record integration into the cloud database for healthcare utilisation, pathology, and demographic data.

Two VOC predictor models were developed and tested using this data; the first previously presented at ASH 2023 (Model 1), and the second a new algorithm utilising an alternative AI framework (Model 2). Model 1’s snapshot cohort included 186 patients, with data captured over 1 month (May-June 2023), while Model 2 included 399 patients and data over 6 months (February-July 2024).

An ensemble of machine learning (ML) models was used: gradient boosting machine (GBM), neural network (NN), and k-means clustering. While Model 1 utilised the Caret ML framework, Model 2 utilised TensorFlow-keras and scikit-learn to enable additional model customisation and feature addition. A daily 0-100% VOC risk prediction was calculated for each patient and mapped against self-reported VOC occurrences. Risks of 75% or higher were considered a predicted VOC.

For Model 1, the 10 variables with the highest importance score, based on how much the variable was used in the NN and GBM, were fatigue, pain score, hydration, treatment (pain medication), pain/discomfort, age, mood score, EQ-5D-5L, EQ-5D Health State, and temperature (environmental). In Model 2, these were pain score, treatment, EQ-5D-5L, temperature, mood score, genotype, sex, EQ-5D Health State, deep sleep proportion, and sleep score.

Results

In Model 1, the mean (SD) age was 36±12 years, with the majority of patients female (70%), and 75% of HbSS genotype. For Model 2, this was 34±12 years, with 70% female and 76% HbSS. 82,804 datapoints were collated for all participants across this period in Model 1 and 1,218,035 in Model 2, encompassing 90 and 107 different variables, respectively.

Within the Model 1 extract, patients self-reported 69 VOCs, the algorithm accurately predicting 58 (84%). Regarding patient-reported instances of ‘no’ VOC, 1,958 of 2,366 were predicted, giving a specificity of 83%. An improvement was seen in Model 2 with a sensitivity of 92% (643/700), and a similar 83% (31,414/37,976) of patient-reported ‘no’ VOCs accurately predicted.

Summary/Conclusions

The currently presented AI model for VOC prediction in SCD demonstrates increased accuracy, serving as a proof-of-concept for remote digital biometric and ePRO tracking as a real-world early warning system for health deterioration. It improves the

model sensitivity from 84% to 92%, reducing the risk of missing these severe events.

Since the previous model, ongoing development has focused on automating data capture, lessening manual input, and reducing patient burden. This aims to minimise missing data and unpredicted VOCs while enabling pre-emptive interventions or behavioural changes. Future work will integrate Model 2 into the ensemble algorithm to further optimise predictive capabilities and thereby help prevent potential hospitalisations.

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