Machine Learning for Detection of Wolff-Parkinson-White Syndrome Using ECG Data

Background
Wolff-Parkinson-White (WPW) syndrome is a rare but clinically significant cardiac condition requiring timely diagnosis to prevent life-threatening complications such as cardiac arrest. Early and accurate detection remains a challenge in clinical practice.

Objective
This study aimed to develop machine learning (ML) models to improve the detection of WPW syndrome using electrocardiograms (ECGs).

Methods
ML models were trained using a development dataset comprising 132,045 patient records (805,938 ECGs) with WPW diagnoses identified through the International Classification of Diseases, 10th Revision (ICD-10) code I456. Model performance was evaluated on an independent cohort of 83,304 patients, using their first ECGs recorded during hospital admissions (227,129 ECGs). Gradient boosting (XGBoost), leveraging ECG measurements, and deep learning methods, analyzing ECG traces, were employed. Model performance was assessed using the area under the receiver operating characteristic curve (AUROC).

Results
The prevalence of WPW syndrome was approximately 0.13% in both the development and test datasets. XGBoost demonstrated the highest performance, achieving an AUROC of 84.69% (95% CI: 81.10%–88.15%).
Notably, the model also identified 21 out of 51 ECGs flagged as normal by ICD-10 coding but exhibiting delta wave signatures in machine-analyzed ECG readings, demonstrating its capability to identify potential WPW cases beyond the limitations of ICD-10 coding.

Conclusion
This study highlights the potential of ML models to replicate and enhance traditional diagnostic pathways, particularly in the early detection of WPW syndrome. Future research could investigate how these models might complement existing clinical workflows by identifying cases overlooked by conventional diagnostic methods, thereby improving diagnostic accuracy and patient outcomes.

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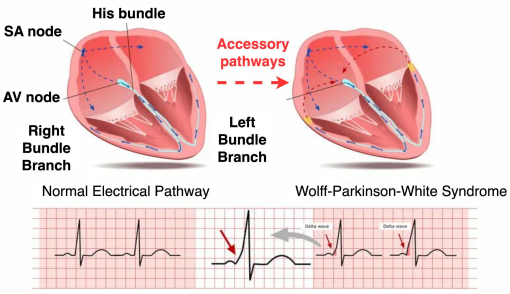
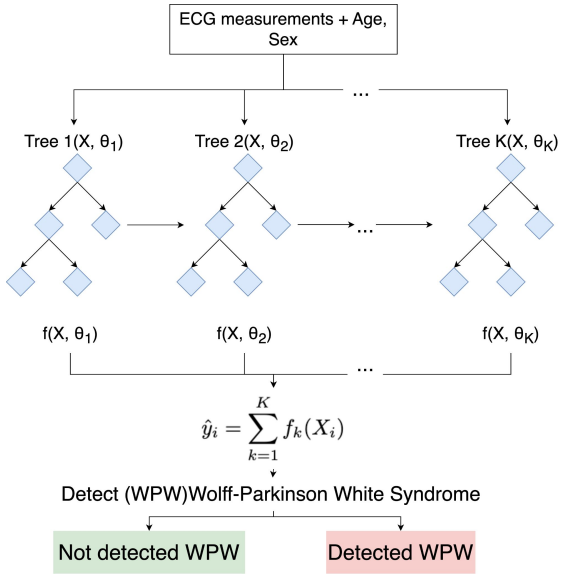
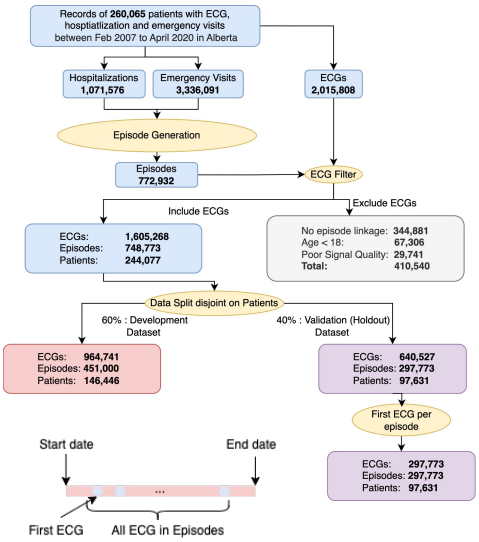
Background & Objectives



- WPW syndrome is an uncommon cardiac disorder that can lead to life-threatening arrhythmias.
- Early detection is vital to prevent severe complications such as sudden cardiac arrest.
- Conventional methods with ECG measurements may lead to low recall compared with ICD 10 diagnosis code from health care episode
- ICD-10 code I45.6 (pre-excitation syndrome) specifically applies to WPW syndrome, providing reliable diagnostic reference.
- Innovative approaches, such as machine learning, hold promise for enhancing diagnostic performance.

Method



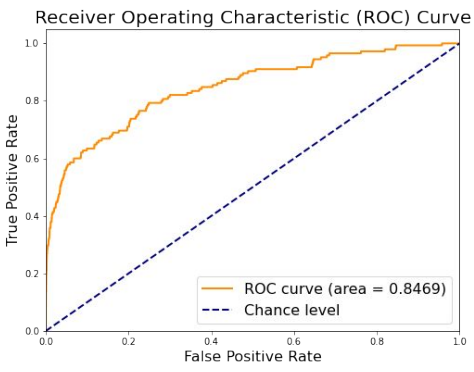


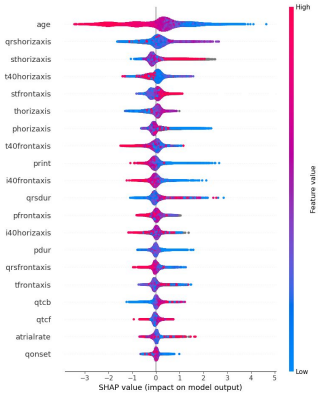
Data Source

ECG	AMBULATORY	INPATIENT	POPULATION REGISTRY
12 lead ECG traces, Acquisition dates	≤ 10 Dx, Emergency use, Specialty clinics	≤ 25 Dx, Admission & Discharge Dates	Demographics Age, Sex

772,932 healthcare episodes (Hospitalization and ED visits), 260,065 patients
452 (0.174%) patients with 2,171 ECGs link Wolff-Parkinson-White Syndrome (I45.6)
2007-2020 from 26 hospitals in Alberta, Canada

Result





Conclusion

- Our WPW XGBoost from ECG measurements achieved a high diagnostic performance with an **AUROC of 84.69%**.
- Compared with **conventional ECG machine-generated statement codes**, our model shows higher recall and captures missed WPW codes.
- SHAP analysis revealed that **low age, high QRS/ST/T horizontal axes, and low T40/P horizontal axes are key discriminators**, underscoring the importance of depolarization/repolarization axis shifts in WPW prediction.