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Artificial intelligence algorithms for the recognition of Brugada type 1 pattern on standard 12-leads ECG

Mr Vozzi F[1].; Mrs Dimitri GM[2].; Doctor Piacenti M[3].; Doctor Zucchelli G[4].; Doctor Solarino G[5].; Doctor Nesti M[6].; Doctor Pieragnoli P[7].; Mr Gallicchio C[2].; Mrs Persiani E[1].; Doctor Morales MA[1].; Professor Micheli A[2].

National Council of Research, Pisa, Italy
University of Pisa, Department of Computer Science, Pisa, Italy
Fondazione Toscana Gabriele Monasterio, Pisa, Italy
Azienda Ospedaliero Universitaria Pisana, Pisa, Italy
USL Toscana Northwest, Viareggio, Italy
San Donato Hospital of Arezzo, Arezzo, Italy
Careggi University Hospital, Florence, Italy

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Background/Introduction: Electrocardiograms (ECGs) are rapidly moving from analog to digital versions. Consequently, a series of automatic analyses of standard 12-lead ECGs are attracting interest for their ability to support clinicians in the automatic recognition of specific features associated with different cardiac diseases [2]. Artificial Intelligence applications and Machine Learning (ML) algorithms have gained much attention in the last years for their ability to figure out patterns from data independently, without being explicitly taught rules. Peculiar features define the ECGs of patients with Brugada Syndrome (BrS); however, ambiguities still exist for the correct diagnosis of BrS and discrimination with respect to other pathologies.

Purpose: The BrAID (Brugada syndrome and Artificial Intelligence applications to Diagnosis) project aims to develop an innovative system for diagnosing Type 1 BrS based on ECG pattern recognition through the application of ML algorithms. In this work, an application of Echo State Networks (ESN), a type of Recurrent Neural Network (RNN), for the diagnosis of BrS from ECG is presented.

Methods: After approval from the Local Ethical Committees, 12-lead ECGs were obtained in patients enrolled in 5 Centers diagnosed with typical spontaneous Type 1 pattern (coved) (group A, 81 patients). Baseline ECG was also collected in patients undergoing the ajmaline test, classified as positive (group B, 37 patients) or negative (group C, 14 patients) according to test results. 174 patients with no clinical and familial history of arrhythmias were considered controls (group D). Data were collected from 4 beats extracted from the ECGs as input to the ESN. The datasets obtained in the different groups were used for the ESN model's training and assessment (testing) through a double cross-validation approach.

Results: As shown in Table 1, the performances using three leads (V1, V2, V3) or V2 only were compared.

The algorithm performance was assessed in all the datasets (group A+B+C+D) and in spontaneous BrS (group A) and controls (group D). A good accuracy (79.21%) was seen when the three leads were considered for groups A and D only; the best test set accuracy (80.20%) was obtained in the case in which V2 only was used as input in all the datasets.

Conclusion(s): In this work, a novel system for diagnosing Type 1 BrS using an ESN approach was developed. Our preliminary results show that this ML model is able to detect ECG patterns associated with Type 1 BrS with good and comparable accuracy both when three leads (79.21%) or V2 only (80.20%) were analyzed. The future availability of larger datasets could improve the model performance, increasing the ESN potentialities as a clinical support system tool to be used in everyday clinical practice.

Table 1. The accuracy, specificity, and sensitivity reported for each dataset group are obtained through double cross-validation.

Dataset Group	Patients Nr.	Leads	Accuracy (%)	Specificity	Sensitivity
A + D	255	V1, V2, V3	79.21 (±2.21)	0.91	0.51
A + B + C + D	306	V1, V2, V3	76.39 (±2.13)	0.86	0.63
A + D	255	V2	77.88 (±2.31)	0.84	0.65
A + B + C + D	306	V2	80.20 (±2.83)	0.86	0.74

Result of ML BrS evaluation in datasets