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Artificial Intelligence For The Automatic Detection of Atrial Fibrillation

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BACKGROUND

Atrial Fibrillation (AF) is associated with stroke. The presence of AF in the general population is not known, partly because patients are often asymptomatic, but also because simple, automated, low-cost screening methods are not available. Further, it is difficult to assess the incidence and prevalence of AF with spot-check ECGs that record for limited duration. Moreover, any effort at a population wide assessment has been limited by the need for human readers, which increases the cost and complexity of mass public health screening methods. On the other hand, AF diagnostics must be reliable. False positive diagnoses of AF have considerable adverse impact, especially given the role of anti-coagulation, antiarrhythmic drug, and procedural interventions should the diagnosis be inaccurate. Many of these inaccuracies are the result of a simplistic assumption about what is, and what is not, AF together with the more ubiquitous limited ability of legacy monitors to discern the details of the atrial signal.

OBJECTIVE

Develop an automatic screening technology to detect AF events that are 10 minutes or longer, with 90% sensitivity, 90% specificity, and better than 95% confidence in the sensitivity and specificity, without conflating the diagnosis of AF with other atrial (or ventricular) arrhythmias that result in RR interval variability. Such a methodology could be employed for broad public health screening.

METHODS

For this work, we used ECG recordings from the Carnation Ambulatory Monitor (CAM) (Bardy Diagnostics, Inc., Seattle, WA). The CAM's P-Wave centric design and low-amplitude signal detection allow for reliable AF detection above and beyond algorithmic approaches to RR interval variability as well as AI efforts dominated by the R-wave signal, both of which can incorporate a host of non-AF arrhythmias as AF. In our system, a convolutional, feed-forward neural net was trained with ambulatory ECG CAM recordings up to 7 days in duration from 73 patients with persistent AF, 24 patients with paroxysmal AF, and 254 patients with no finding of AF. Included in the 254 were 103 patients with dense atrial or ventricular ectopy, atrial flutter and atrial tachycardia with variable conduction who were included as specific counter-examples in the no-AF training category. The importance of this distinction relates to the differences in medical and procedural management of these various disorders as well as their differences in stroke risk. The total training population comprised 351 patients.

VALIDATION

The data was segmented into uniform length samples yielding 4,969,056 AF-positive samples and 7,081,180 AF-negative samples on which the neural net was trained. Validation of the neural net was performed using a separate population of 206 AF-positive patients and 268 AF-negative patients who were not involved in training, with physician and nurse confirmation of AF presence and duration.

RESULTS

The detector differentiates AF not only from normal sinus rhythm, but also from other conditions that cause beat-to-beat variation such as dense atrial ectopy, dense ventricular ectopy, atrial flutter with variable conduction, and atrial tachycardia with variable conduction. These latter rhythms are conditions commonly mistaken for AF using RR variability algorithms and AI approaches without P-wave centric ECG design. Our overall expert-validated sensitivity was 95% with a confidence of 99%, and the specificity was 91% at a confidence of 98% for detecting 10 minutes of AF or longer.

LIMITATIONS

There are two limitations to this work. First, the findings are limited to a P-wave centric ECG monitor. Second, durations of AF less than 10 minutes will have a lower sensitivity and specificity. Efforts are being made to decrease the 10 minute limit further. That said, precise information regarding risk and AF duration in the non-pacemaker population is not known. Durations of AF that are >10 minutes may be too short when considering use of such algorithms for public health screening purposes. That said, it is unlikely that duration of AF, as it relates to risk, will be understood fully without folding additional clinical measures into a risk-profile.

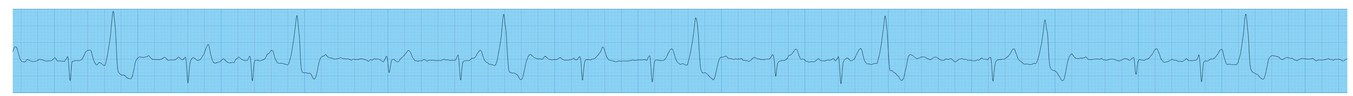
CONCLUSIONS

Our P-wave centric continuous ECG monitoring technology allows our neural network to differentiate between AF and a host of rhythms with RR interval variability that are not AF, because of our ability to bring detailed quality and character to the atrial ECG. This reliable and expert-validated AI approach makes it possible to screen the public for atrial fibrillation, which can lead to further insights about treatment options to reduce risk of stroke.

DETECTION RESULTS

Wenckebach Block

Trigeminy

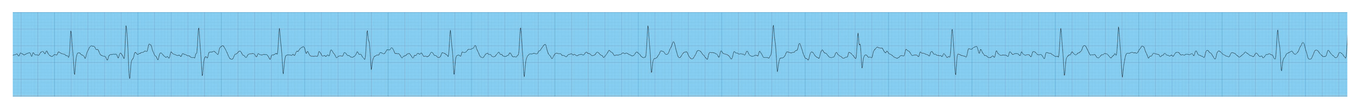


Trigeminy with AF *(positive detection – shaded)*

From same patient as directly above

Dense Atrial Ectopy

Ectopic Atrial Rhythm



Atrial Fibrillation *(positive detection – shaded)*

Normal Sinus Rhythm

AFL with Variable Conduction

Blocked PACs

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