Validation and clinical use of a novel diagnostic device for screening of atrial fibrillation

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Aims	Patients with asymptomatic and undiagnosed atrial fibrillation (AF) are at increased risk of heart failure and ischaemic stroke. In this study, we validated a new diagnostic device, the MyDiagnostick, for detection of AF by general practitioners and patients. It records and stores a Lead I electrocardiogram (ECG) which is automatically analysed for the presence of AF.
Methods and results	In total, 192 patients (age 69.4 $\pm$ 12.6 years) were asked to hold the MyDiagnostick for 1 min, immediately before a routine 12-lead ECG was recorded. Atrial fibrillation detection and ECGs stored by the MyDiagnostick were compared with the cardiac rhythm on the 12-lead ECG. In a second part of the study, the MyDiagnostick was used to screen for AF during influenza vaccination in the general practitioner's office. Atrial fibrillation was present in 53 out of the 192 patients (27.6%). All AF patients were correctly detected by the MyDiagnostick (sensitivity 100%; 95% confidence interval 93–100%). MyDiagnostick AF classification in 6 out of 139 patients in sinus rhythm was considered false positive (specificity 95.9%; 95% confidence interval 91.3–98.1%). During 4 h of influenza vaccination in 676 patients (age 74 $\pm$ 7.1 years), the MyDiagnostick correctly diagnosed AF in all 55 patients (prevalence 8.1%). In 11 patients (1.6%), AF was not diagnosed before, all with a CHA_2DS_2VASc score of >1.
Conclusion	The high AF detection performance of the MyDiagnostick, combined with the ease of use of the device, enables large screening programmes for detection of undiagnosed AF.
Keywords	Atrial fibrillation • Screening • Electrocardiogram

Introduction

Atrial fibrillation (AF) is the most common arrhythmia, with a prevalence rising from 0.7% in the age group 55–59 years to 17.8% in those aged $\geq$85 years.[1] With ageing populations, the prevalence of AF will increase substantially during the next decennia. In persons $\geq$65 years, screening studies reveal an AF prevalence of 4.4%, with 1.4% having previously undiagnosed AF.[2] In a recent study of ambulant patients $\geq$65 years, 6.7% were in AF and in 10% of those, AF was incidentally detected, mostly without symptoms.[3] The consequence of undiagnosed AF is that these patients are not receiving any treatment. This leads to an increased risk of heart failure due to uncontrolled ventricular rates and ischaemic stroke. The annual stroke risk in AF patients not treated with anticoagulants is 5%, which is two to seven times as high compared with non-AF patients. A recent pacemaker study revealed an increased stroke risk in patients with device-detected silent AF.[4] In a stroke registry, we demonstrated that 45% of all AF-related strokes occurred in patients with asymptomatic and unknown AF.[5] After diagnosis of AF, treatment with vitamin-K antagonists (coumarins) or the new oral anticoagulants like dabigatran, rivaroxoban, or apixaban will reduce stroke risk.[6–8] Screening for AF and initiation of anticoagulation in patients at risk may have a big impact on the total number of ischaemic strokes.[9] However, for the diagnosis of AF, demonstration of the arrhythmia on an electrocardiogram (ECG) is obligatory. Regular 12-lead ECG recording is expensive and labour-intensive. Furthermore, due to the paroxysmal nature of AF, surveillance ECGs during GP or cardiologist visits are not sensitive enough to detect all AF.[10] Because of the limited duration of the recording, also 24 h. Holter monitoring is not an ideal diagnostic instrument to confirm (paroxysmal) AF.[11]

What's new?

- A novel device for detection of (asymptomatic) atrial fibrillation is presented and clinically validated for performance compared with the 12-lead electrocardiogram (ECG, Gold standard).
- This new device facilitates screening of large patient groups with minimal work load for the health care professional, since patients can screen their own rhythm and only need to contact the professional in case of a high suspicion of AF, as indicated by the red light. Furthermore, no additional 12-lead ECG recording is required for confirmation of the diagnosis, as this can be done on the stored ECG.
- First time clinical use of this new device (the MyDiagnostick) during influenza vaccination showed a diagnostic yield of 1.6% silent AF.

Several studies have shown that long-term repeated opportunistic monitoring of patients with cryptogenic stroke increases the sensitivity of AF detection.[12–15] This need for screening requires new diagnostic devices that allow quick and easy measurement of the ECG and detection of AF without the need of any infrastructure.

Methods

In this study, a new diagnostic device has been validated enabling multiple ECG measurements and automated detection of AF by general practitioners and patients. In a second part of the study, the MyDiagnostick was used to screen for the presence of AF in a high-risk population during influenza vaccination.

MyDiagnostick

The MyDiagnostick (www.mydiagnostick.com, MyDiagnostick Medical BV) is intended to discriminate AF from a normal cardiac rhythm (normal sinus rhythm, NSR) based on the ECG. This is achieved by an easy accessible device that can be used by both care providers like general practitioners, nurses, cardiologists and patients. The device has the shape of a stick (length 26 cm, diameter 2 cm) with metallic electrodes at both ends as shown in *Figure 1*. The MyDiagnostick does not depend on any infrastructure or communication channels and can be used anytime, anywhere by simply holding the device in both hands for 60 s until the result is revealed. While holding the device, it will flash on the rhythm of the detected heartbeat. After 1 min, the MyDiagnostick either turns green, indicating a normal cardiac rhythm, or red in the case of AF. The MyDiagnostick has no buttons to select functions and switches automatically on when holding the device and will switch off after it has revealed the diagnostic result (red or green light) to the user. Due to the intuitive nature of the MyDiagnostick, diagnosis for AF can be started almost immediately and will reveal the result within 1 min. The algorithm is designed in such a way that it will diagnose AF in case the arrhythmia is present during at least 75% (45 s) of the 1 min ECG recording. The MyDiagnostick will store up to 140 1 min ECG Lead I strips. A priority storage scheme is implemented in the MyDiagnostick aiming at storage of the most recent AF episodes. When more than 140 recordings are made, only the non-AF ECGs are overwritten, unless all non-AF strips are replaced by AF recordings. This allows for long-term autonomous use of the device without the burden of loosing relevant ECG data. Time and date stamped stored ECGs can be made available by returning the MyDiagnostick to the physician, who can connect it to a web-portal (USB connection to internet enabled PC, *Figure 2*). The MyDiagnostick web portal enables organization of episodes per patient, printing and sharing of ECGs and diagnostic results with other physicians. When the MyDiagnostick is used during high-turnover situations like screening sessions, the physician will be alerted by the red light in case of AF detection. The MyDiagnostick can be interrogated immediately, and the computer can be programmed to show the last recorded ECG to which the patient's name can be added. Alternatively, the physician records time and date and the patient's personal data in a screening logbook in case of a red light, and ECGs can be labelled and analysed at the end of the screening session. The rechargeable battery allows for more than 300 recordings on a single charge, or 2 months regular use of the device while measuring three to five times per day.

Patients and protocol

We included at random 192 patients, 48.4% male, age 69.4 $\pm$ 12.6 years, visiting the outpatient cardiology clinic or a specialized AF outpatient clinic.[16] Patients were asked by the nurse to hold the MyDiagnostick for 1 min, immediately before a routine 12-lead ECG was recorded. Date and time of the MyDiagnostick were synchronized with the time of the 12-lead ECG device. Automated AF detection and stored ECGs by the MyDiagnostick were compared with the cardiac rhythm based on the 12-lead ECGs, which were analysed by a cardiologist (RT) blinded for the MyDiagnostick AF outcome.
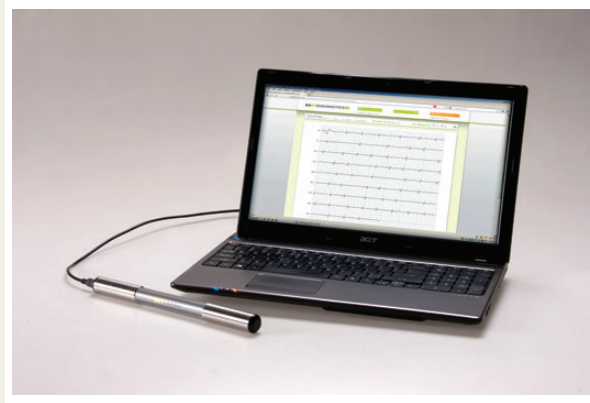

Figure 2 The MyDiagnostick system including the device and a stand-alone PC application or internet-based web portal for interrogation of the device and storage of the ECG data enabling printing and sharing of ECG data. Furthermore, the web portal allows preparation setup of the MyDiagnostick device. The heartbeat and diagnosis indicators can be switched on or off separately enabling blinding of analysis results to the patient.

Figure 1 The MyDiagnostick device.

In the second part of the study, patients undergoing influenza vaccination at two general practitioner offices were asked to check their heart rhythm using the MyDiagnostick. Detection of AF was confirmed by analyses of the stored ECGs from the stick by a cardiologist (RT) and new cases of AF were identified.

Results

From the 192 patients visiting the outpatient clinic (one recording each), AF was confirmed on the 12-lead ECG by the cardiologist in 53 patients (27.6%). The MyDiagnostick was able to perform a reliable recording and analysis in all patients. All AF patients were correctly detected by the MyDiagnostick (sensitivity 100%; 95% confidence interval 93–100%). MyDiagnostick AF classification in 6 out of the 139 recordings during sinus rhythm was considered false positive (specificity 95.9%; 95% confidence interval 91.3–98.1%). In the subgroup of patients ≥ 65 years ($n = 144$), the specificity increased to 97.0% (95% confidence interval 91.5–99.0%). The actual rhythm on the 12-lead ECG in the false-positive cases was frequent premature atrial or ventricular complexes with an irregular coupling interval in three patients, sinus arrhythmia in one patient, and atrial flutter with an irregular ventricular response in two patients. In four other patients with atrial flutter, the MyDiagnostick correctly diagnosed the absence of AF. *Figure 3* shows examples of 1 min episodes of NSR and AF recorded by the MyDiagnostick (ECG Lead I). During NSR (*Figure 3*, left panel), a regular rhythm is observed with clear P-waves preceding the QRS complex. During AF (*Figure 3*, right panel), characteristic irregularity of RR intervals and wiggling of the baseline are evident. *Figure 4* shows two examples of false-positive detections of AF during an episode of NSR with frequent premature ventricular contractions (left panel) and atrial flutter with an irregular coupling interval (right panel).

In the second part of the study, we used the MyDiagnostick to screen 676 patients (age 74 ± 7.1 years) during 4 h of influenza vaccination. In 61 patients (age 70.1 ± 5.2 years), the MyDiagnostick diagnosed the presence of AF. Analyses of the stored ECG by the cardiologist confirmed the correct diagnosis in 55 patients (prevalence 8.1%). Forty-four patients (6.5%) were known with AF, but in 11 patients (1.6%), AF was not diagnosed before. Importantly, all 11 patients had a CHA_2DS_2VASc-score of >1 requiring anticoagulation (mean CHA_2DS_2VASc-score of 3), while none of these patients were anticoagulated at the time of diagnosis. Six patients had a false-positive reading, three because of sinus arrhythmia (all young patients), one patient because of a tremor, and two because of the presence of frequent supraventricular extra-systoles (specificity 99%). Analyses of the stored 615 ECGs in which the MyDiagnostick revealed the absence of AF confirmed the correct diagnosis in all, in line with the 100% sensitivity found in Phase I of the study.

Discussion

This study presents clinical validation results from evaluation of a new device for detection of AF, the MyDiagnostick. An important design goal for the device was to detect AF with 100% sensitivity. The study results showed that this design goal was achieved while maintaining a high specificity, 95.9%. The specificity was slightly higher, 97.0%, in the subgroup of patients ≥ 65 years, the age group of AF patients most prone to the risk of thromboembolism, and therefore most suitable for screening.

Use of the MyDiagnostick during influenza vaccination was feasible and this detected the presence of AF in 8.1% of the patients screened. In one-fifth of these patients, arrhythmia was not detected before.

Measurement method

The MyDiagnostick enabled rapid acquisition and analysis of 1 min long segments of ECG recordings. The ease of use of the MyDiagnostick was confirmed by our study participants who were able to use the device with only minimal instructions; 'please hold the stick with

Figure 3 Electrocardiogram tracings recorded by the MyDiagnostick. Left: normal sinus rhythm. Right: AF.

Figure 4 False-positive ECG tracings recorded by the MyDiagnostick. Left: an example of normal sinus rhythm with frequent premature ventricular extra-systoles. Right: an example of atrial flutter with an irregular coupling interval.

both hands for 1 minute and please report the color of the light; is it green or red.' In contrast to other solutions including smartphone and blood pressure devices,[17,18] recording and reliable analysis of the ECG for detection of AF is embedded in the MyDiagnostick. This allows patients to monitor their rhythm anywhere-anytime, without the need for a communication channel, base station, or support from a health care professional. The 100% sensitivity allows the health care provider to only check the red-labelled ECGs to see whether the MyDiagnostick correctly identified AF. The high specificity prevents frequent 'false alarm', minimizing patient's anxiety and workload for the health care professional.

Clinical utility

The need for improved detection of silent AF is demonstrated by the fact that in almost half of the patients with an AF-related stroke, arrhythmia has been found to be asymptomatic and undiagnosed, and therefore untreated.[5] The ease of use of the MyDiagnostick and high AF detection accuracy combined with a low rate of false positives will promote a high patient compliance and enhance the utility of the device for AF detection in individual patients as well as in large population-based AF screening programmes. Another cost-effective indication could be outpatient cardiac monitoring for identification of paroxysmal AF in patients after ischaemic stroke.[19]

The use of the MyDiagnostick in opportunistic screening may also improve the identification of asymptomatic patients with AF. It is advisable in these programmes to take advantage of the CHA_2DS_2-VASc score, since these patients have a higher incidence of AF and all require anticoagulation in case the AF is diagnosed.[20,21] The general practitioner could screen all patients >65 years, and in the setting of cardiovascular risk management in patients with a history of hypertension, diabetes mellitus, vascular conditions, or an ischaemic stroke. Other screening opportunities to be considered include the geriatric or internal medicine clinic, the neurologist's office, or nursing homes.

Limitations

The MyDiagnostick records an ECG using Lead I and uses this ECG for classification of the cardiac rhythm. Electrocardiogram quality may suffer from a resting tremor (e.g. Parkinson's disease), very dry hands, or a vertical heart axis. In that case, the MyDiagnostick will usually indicate an error sign (flashing the on/off LED). Careful instruction, wetting of the hands, or a change in posture may overcome most of these problems making adequate ECG analysis possible. Furthermore, due to the design of the MyDiagnostick, it only classifies the actual heart rhythm during use of the device. Asymptomatic episodes of paroxysmal AF may still be missed. Repeated recordings may eventually pick up these paroxysms.

Conclusion

This study demonstrates a 100% sensitivity and a 95.9% specificity for detection of AF by the MyDiagnostick, a device developed for screening and documentation of AF. When used during influenza vaccination, a new AF diagnosis was made in 1.6% of the patients. These results, in combination with the simplicity of handling of the device, may enable large screening programmes in the near future.

Acknowledgements

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