Remote ECG Interpretation – Guidelines and Their Implementation

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Abstract

Objective: e-Health is a relatively new medical trend, already finding place in clinical practice guidelines. Clinical cardiologists, however, are still not comfortable enough with interpreting, assessing and refining alarms and other information received remotely, in their practice.

Prolonged ECG monitoring in stroke survivors enables the detection of episodes of silent atrial fibrillation (AF). Our aim in the present study is to prove the usefulness of e-Health implementation to detect silent AF in stroke survivors, as recommended in recent guidelines.

Methods and results: We prospectively included 54 patients (mean age 54±15 years, 17% women) with cryptogenic stroke, without previously documented episodes of AF. We performed remote ECG monitoring for 22 days (range: 13-36 days). AF was detected in 14 patients (26%), mostly asymptomatic (64%) which prompted initiation of anticoagulation therapy. The mean time from initiation of telemonitoring to AF detection was 10 days (2-29 days).

Conclusion: e-Health implementation via remote ECG monitoring, as recommended by recent ESC guidelines, is a very useful and easily applicable medical tool, enabling AF detection in at least one in every four stroke patients.

1. Introduction

e-Health is described as the use of information and communication technologies in the support of health and health-related activities [1]. It is a relatively new medical trend, already finding place in clinical practice guidelines - remote use of information and communication technology is mentioned as an alternative to care delivered by health professionals in person. However, clinical cardiologists need to be more comfortable with interpreting, assessing and refining alarms and other information received remotely, in their practice of guidelines.

European Society of Cardiology (ESC) guidelines on the management of atrial fibrillation (AF) [2] support prolonged ECG monitoring (for 72 h or longer periods) to enhance detection of undiagnosed AF. Detection of asymptomatic AF by innovative technologies, such as smartphone cases with ECG electrodes, smart watches, and blood pressure machines with AF detection algorithms, has not yet been formally evaluated against an established arrhythmia detection method [3].

Stroke still represents a major health problem and its prevalence and incidence are estimated to increase [4]. The Framingham Study showed that 1 in 5 women and 1 in 6 men aged 55 to 75 years will experience stroke sometime during their life [5].

Approximately one of four strokes are considered cryptogenic. In these cases, identifying AF as a main pathogenic factor in the embologenic etiology is a key priority in secondary stroke prevention because of important treatment implications [6, 7]. Introducing anticoagulation therapy with vitamin K or non-vitamin K oral anticoagulants results in a relative stroke risk reduction of 64% and all-cause mortality is also significantly reduced by 26% versus control, according to the results of a meta-analysis [8].

Prolonged ECG monitoring in stroke survivors enables AF detection in up to one quarter of patients and this has an important implication on therapy and secondary prevention [9]. Therefore, ESC guidelines give a high priority to additional ECG monitoring by long-term non-invasive ECG monitors or implanted loop recorders to document silent atrial fibrillation [2].

Our aim is to prove the usefulness of e-Health implementation to detect silent AF in stroke survivors, as recommended in recent guidelines.

2. Methods

2.1. Study group

This was a prospective study of ambulatory patients. We screened patients with stroke or transitory ischemic attack (TIA) and those of them who were deemed eligible entered a telemonitoring period after dehospitalization.

Patients could be included if they were ≥ 18 years of age and had an ischemic stroke (CT/MRI verified) or transitory

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ischemic attack (symptoms for less than 24 hours and no CT/MRI data for ischemic lesion) in the last 3 months before inclusion. Eligible patients should not be significantly disabled or dependant for their daily activities - modified Rankin score ≤ 3.

Exclusion criteria were history of AF, significantly shortened life expectancy, permanent pacemaker, anatomical deformities precluding monitoring device installation, presence of absolute contraindications for antithrombotic prophylaxis, history of haemorrhagic stroke.

We have not included patients with positive findings for potential atheroembolic sources, such as aortic atheromatosis or carotid artery pathology. Presence of patent foramen ovale or aneurismal atrial septum deformation was an also exclusion criterion. Patients with diagnosed prothrombotic state (antiphosphoplipid syndrome, protein C or S deficiency, factor V Leiden, homocystinemy etc) were not included.

2.2. Telemonitoring

Telemonitoring was performed with a system, validated versus standard ECG and Holter ECG [10] and consisting of a mobile handheld device for recording and transmitting data and an elastic belt, placed on the chest, for registering precordial electrical activity of the heart and detecting R-R intervals. Data from the belt is transmitted wirelessly to the mobile device. The handheld device is used also to record demand ECGs (single-channel ECG) which is easily achieved by the patient: placing the device to the chest and pressing a button.

Within 5-minute intervals, recorded data is transmitted to an electronic center by GSM network, for further analysis and visualization.

The mobile device has also an accelerometer for detection of physical activity (and therefore can differentiate between resting condition and physical exertion) simultaneously with R-R interval detection.

The electronic center consists of a server with developed software for automatic RR interval analysis [10, 11] – for rhythm detection (including atrial fibrillation), heart rate and premature beats. The algorhythms and software have been validated during development and afterwards on MIT ECG database. The electronic center is accessible via Internet, from any PC or smartphone with security access to the system. The telemonitoring system has the possibility to alert via SMS the monitoring physician and the patient in case of significant deviation from normal values (e.g. heart rate less than 40 beats per minute, AF episode, etc). All software detected AF episodes were further validated by a physician.

2.3. Ethics

All patients signed an informed consent. The study is in accordance with the Declaration of Helsinki.

2.3. Statistics

We tested the distribution of continuous variables using the Kolmogorov-Smirnov test. Normally distributed data were presented as mean ± standard deviation (SD), whereas non-normally distributed data – as median and interquartile range (IQR) (the difference between the 25th and 75th percentile). Categorical variables were presented in percentage terms. Statistical analysis was performed using SPSS statistical software for Windows version 13.0.

3. Results

We evaluated 54 patients, 9 of them (17%) were women, mean age in our group was 54 ± 14 years. Risk factor distribution, past medical history and baseline therapy are presented in table 1.

Table 1. Baseline characteristics of the study group

Parameter	Distribution
Arterial hypertension - n (%)	38 (70%)
Dyslipidemy - n (%)	36 (67%)
Diabetes mellitus - n (%)	17 (32%)
Smokers - n (%)	33 (61%)
Body mass index - median (25th - 75th percentile)	24.7 (20.5-28.9)
Coronary artery disease - n (%)	12 (22%)
History of arrhythmia - n (%)	21 (39%)
Heart failure - n (%)	2 (4%)
Acetylsalicylic acid - n (%)	25 (46%)
Beta blockers - n (%)	15 (28%)
ACE inhibitors - n (%)	20 (37%)
Angiotensin receptor blockers - n (%)	0
Calcium channel blockers - n (%)	10 (19%)
Statins - n (%)	10 (19%)
Clopidogrel - n (%)	26 (48%)

Mean CHA2DS2-VASc score in our group was 3.44 ± 1.08. Echocardiographic findings showed that mean ejection fraction in our group was 59.8 ± 9.5%. Ten of the patients (19%) had an ejection fraction <50%. Mean indexed left atrial volume was 29.5 ± 18.6 ml/m^2 and ten patients (19%) had marked left atrial enlargement, defined as left atrial volume index >34 ml/m^2. Mitral regurgitation was present in 11 patients (20%), mild in 7 of them (13%) and moderate degree in 4 patients (7%).

No one of the patients had aortic atheromatosis or carotid artery pathology. All patients were in sinus rhythm at the moment of their baseline ECG registration.

Mean NIH Stroke scale was 5.3 ± 2.4.

Telemonitoring was performed for a median time of 22 days, ranging from 13 to 36 days. During this time, we detected AF episodes lasting up to 30 secs in 10 patients of the study group (19%). Longer AF episodes were present in 4 other patients (7%) - Figure 1 and Figure 2. Combining all AF episodes registered during telemonitoring, more than one fourth (26%) of our group of cryptogenic stroke patients turned out to suffer from this rhythm disorder. The mean time from initiation of telemonitoring to AF detection was 10 days, ranging from 2 to 29 days.

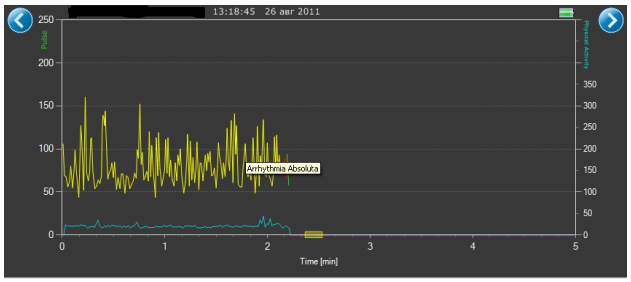

Figure 1. A two-minute episode of AF, yellow trace, during a five-minute telemonitoring window. The yellow trace is depicting the heart rate and its variability. The blue trace is accelerometer recording, representing the physical activity; in this case, the patient is resting.

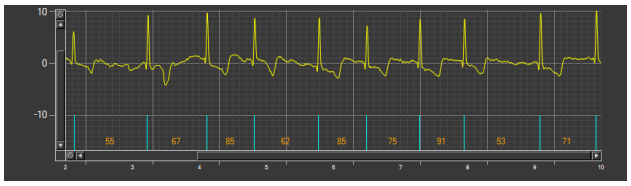

Figure 2. Single-channel ECG made on patient's demand (the small yellow rectangle on Figure 1 represents the time window for the ECG recording, made on patient's demand). The ECG shows AF, which verifies the arrhythmia. The blue vertical lines bellow the ECG are markers of QRS complexes, as detected by the software. Beat-to-beat heart rates corresponding to the RR intervals are visible on the pannel.

Five of the patients had symptomatic AF episodes with symptoms coinciding with previous history of undocumented arrhythmia. The other nine (64% of the group with AF) had asymptomatic runs of absolute arrhythmia.

Therapy was modified in all 14 persons with AF detected during telemonitoring. Anticoagulants (either vitamin K antagonists - Sintrom, or novel anticoagulants such as the thrombin inhibitor dabigatran or factor Xa antagonists: rivaroxaban or apixaban) were included in the therapy.

4. Discussion

In the present study, we found that e-Health could be implemented in the care of patients with a history of stroke of unknown etiology (cryptogenic stroke). It enabled detection of AF episodes (mostly silent) in 26% of our study group of people without a history of cardiac rhythm disorders.

It has to be mentioned that the mean time from ECG remote monitoring initiation to first AF episode detection was 10 days. This means that a standard 24- or even 48-hour Holter ECG would not have had the necessary diagnostic yield to detect AF in this population.

Silent, undetected episodes of AF are common, with severe consequences such as stroke and death [12]. Even in the general population, screening of people at a mean age of 64 years yielded a prevalence of 2.3% for the chronic forms of AF using only short-term ECG recordings or pulse palpation [13]. Implementing long-term ECG recordings and remote monitoring would have enabled detection of paroxysmal forms of AF and would have increased considerably the prevalence.

Silent AF is even more common in high risk population, such as those with heart failure or stroke survivors. EMBRACE trial showed that among patients with a recent cryptogenic stroke or transitory ischemic attack who were 55 years of age or older, noninvasive ambulatory ECG monitoring for a target of 30 days significantly improved the detection of atrial fibrillation by a factor of more than five and nearly doubled the rate of anticoagulant treatment, as compared with the standard practice of short-duration ECG monitoring [9].

The results of our study confirm the high rate of AF detection (predominantly silent AF) in patients with cryptogenic stroke, revealing even higher AF prevalence in this population –one in every four people. The findings are of utmost importance, since initiating anticoagulation therapy in these patients (who by default have a CHA_2DS_2-VASC score of at least 2, having a history of stroke) is a major factor preventing recurrent stroke or peripheral embolization.

Such findings are the reason for the high class of indication for long-term ECG monitoring in current ESC guidelines for AF management: ECG monitoring for at least 72 hours for AF screening after transitory ischemic attack or ischemic stroke gets class I indication, while long-term non-invasive ECG monitors and implantable loop recorders to document silent AF in stroke patients have a class of indication IIa.

Remote ECG monitoring in AF patients, however, has further applications, beside the detection of silent AF in stroke survivors. Once the ECG diagnosis of AF has been established, further ECG monitoring can help clinicians to manage their patients, allowing timely detection of a change in symptoms or new symptoms, suspected progression of AF, monitoring of drug effects on

ventricular rate and monitoring of antiarrhythmic drug effects or catheter ablation for rhythm control [2].

e-Health has the potential to provide innovate solutions to health issues, enabling technology to improve care and the experience of care. Therefore e-Health is the ideal partner for a physician who takes care of stroke patients and / or AF patients. Telemonitoring in these populations is a safe, convenient and very effective way to discover and solve problems the moment they appear. e-Health provides a patient-oriented, point-of-care health service delivery, since behind all of this stands the individual (or patient), who is increasingly familiar with information and communication technologies and expects to find it supporting modern healthcare delivery, facilitating more personalized and person-centered care at the right time and in the right place.

5. Conclusion

e-Health implementation in patients with cryptogenic stroke using remote long-term non-invasive ECG monitoring, as recommended by recent ESC guidelines, is a very useful, safe and easily applicable medical tool, enabling AF detection in at least one in every four stroke patients and initiating potentially life-saving therapy as secondary prevention.

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