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Atrial fibrillation detection using a automated electrocardiographic monitoring in a transient ischaemic attack service

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ABSTRACT

Background The vast majority of the transient ischaemic attacks (TIA) services in UK reported significant delays in the initiation of the routine cardiac monitoring that may result in a significant number of missed atrial fibrillation (AF) paroxysms and increased long-term risk of recurrent stroke. Automated continuous ECG monitoring (ACEM) system has shown promising results in terms of AF detection but it is unclear if ACEM improves AF detection in a rapid outpatient TIA service.

Objectives We assessed ACEM in patients with TIA with the aim to significantly reduce the delay to initiate the cardiac monitoring and to enhance the yield of AF detection in these patients. We also aimed to determine the impact of a more rapid initiation of ACEM on the 6-month risk of recurrent stroke/TIA.

Methods This is an observational, prospective before (phase 1: 1 July to 31 December 2018) versus after (phase 2: 1 January to 30 June 2019) study of the effect of ACEM, compared with routine initiation of 24h-Holter ECG, in patients with TIA assessed in our service.

Results The phase 1 (n=136) and phase 2 (n=105) cohorts did not differ with regards to age, risk factors, duration of cardiac monitoring. The rate of newly detected AF was significantly higher in phase 2 compared with phase 1 (9.52% vs 2.21%, p<0.001). The 6-month risk of recurrent stroke/TIA was significantly lower in phase 2 compared with phase 1 (7.4% vs 1%, p=0.018).

Conclusions Early initiation of ACEM improves AF detection after TIA in a rapid TIA service and is associated with a reduced risk of recurrent TIA/stroke.

INTRODUCTION

Transient ischaemic attacks (TIAs) are considered as part of the spectrum of ischaemic stroke given the common aetiological pathways and risk factors.[1] Cardioembolism accounts for 17%–30% of all ischaemic stroke and TIAs[2–4]; in particular atrial fibrillation (AF) represents more than 50% of the causes of cardioembolism.[5] It is noteworthy also that a similar proportion of patients with stroke might unknowingly have unrecognised AF.[6] Compared with patients without AF, those with the disorder have a five times higher risk of stroke.[7] Hence, the rapid detection of AF after TIA is crucial because the use of oral anticoagulant can reduce the risk of stroke in patients with TIA with AF by up to two-thirds.[8 9]

Although in many healthcare systems there has been a mounting emphasis on developing dedicated services for patients with TIA,[10–13] limited resources are allocated to perform cardiac evaluations rapidly in patients with TIA. The vast majority of the TIA services in the UK reported significant delays in the initiation of the routine cardiac monitoring that may result in a significant number of missed AF paroxysms.[14]

The automated continuous ECG monitoring (ACEM) system is a relatively new telemedicine service software based on R–R interval dynamic analysis providing automated AF detection. ACEM has a 99% sensitivity and specificity compared with the routine Holter ECG in the presence of manifest AF on ECG data.[15 16] ACEM-Holter has also the advantage that can be performed at the stroke physician's office without sending the patient to the Cardiology Department.

The objective of this quality improvement report was to assess the effect of the use of ACEM in patients with TIA with the aim to significantly reduce the delay to initiate the cardiac monitoring and to enhance the yield of AF detection in these patients. We also aimed to determine the impact of a more rapid initiation of ACEM, compared with the standard of care such as the cardiac monitoring, on the 6-month risk of recurrent stroke/TIA in patients with TIA assessed in our rapid outpatient service.

METHODS

Context

Local general practitioners (GPs) in primary-care or accident and emergency departments can refer any patient they suspect had a TIA but whom they did not consider required

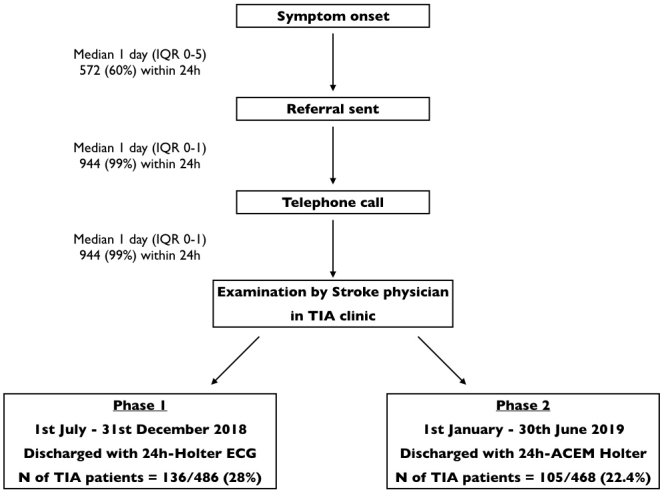

Figure 1 Time from symptom onset to telephone call and to examination in our TIA clinic. ACEM, automated continuous ECG monitoring; TIA, transient ischaemic attack.

immediate hospital admission, to the rapid TIA service at Charing Cross Hospital, Imperial College NHS Healthcare Trust, London (UK) (figure 1). These patients or the caregiver at home (usually by telephone) are then contacted by our team to arrange a clinic appointment within 24 hours of referral received. Our TIA clinic is organised to provide a standardised assessment to all our patients. On the same day, blood tests (lipid profile, red blood cell, white blood cell, platelet count, concentration of glucose, haemoglobin A_{1c}, C reactive protein, creatinine), ECG, brain imaging (usually CT), and carotid ultrasound imaging and a clinical assessment by a stroke physician are obtained. Patients are discharged at home immediately after the assessment, unless the treating physician believes the patient requires urgent admission to our hyper acute stroke unit (HASU). Patients who are discharged with a diagnosis of TIA from our service are then contacted by our Cardiology Department, Imperial College NHS Healthcare Trust, to have a 24h-Holter ECG placed during a scheduled appointment.

Local challenges in implementation

The project had several implementation challenges with multiple stakeholder involvement for the large-scale use of ACEM in our TIA service. According to an internal audit conducted on 136 patients with TIA assessed in our TIA clinic between 1 July and 31 December 2018 (phase 1), the median time interval to initiate the 24h-Holter ECG was 62 days (IQR 13–111). The rate of newly detected AF was 2.21% (3/136) and 7.4% of the patients (10/136) had a recurrent stroke/TIA within 6 months. We decided to use ACEM technology to significantly improve the delay to initiate the cardiac monitoring and to enhance the yield of AF detection in these patients and to reduce the 6-month risk of recurrent stroke/TIA.

Brainstorming meetings with all the TIA team members helped to develop a protocol and to find dedicated clinic space. Stroke clinical nurse specialists were trained to initiate the ACEM-Holter and to remove them after the recording. Stroke physicians were trained to use these new automated health tools, to send the traces via the secure internet connection and to read and interpret the results. We involved physicians and all the other health professionals to participate in this novel care delivery strategy process from very early on. This helped to create ideas to avoid the need for additional resources. Information Governance Department and the Information and Communication Technology Department at Imperial College NHS Healthcare Trust, London (UK) made a secure internet connection to send the ACEM-Holter traces to a central server (Apoplex Medical Technologies, Pirmasens, Germany) in order to respect privacy, security and data confidentiality of the patients involved in this project. They also ensured that all our infrastructure was in place to integrate this new technology.

Study intervention

Between 1 January and 30 June 2019 (phase 2) an ACEM-Holter was applied for 24 hours to all the patients with TIA immediately after their assessment in our clinic at the stroke physician's office without sending the patient to the Cardiology Department. The day after patients returned in our clinic and the stroke physicians (LD or DK) sent the ACEM-Holter traces via a secure internet connection to a central server (Apoplex Medical Technologies, Pirmasens, Germany) where an automated AF episode detection algorithm was applied using the SRAclinic software. This software uses an algorithm that detects QRS complexes of the ECG data and then classifies them as being of atrial or ventricular origin and finally creates a list of R–R-intervals.[15] To detect episodes of AF, the software performs a time series analysis of multiple mathematical parameters that are typical for an absolute arrhythmia during AF. The SRA algorithm consists of three main steps in identifying possible AF. In the end, this results in a final classification into one of the following three groups: (1) no evidence of AF; (2) increased risk of AF or (3) presence of manifest AF. SRA clinic detection of manifest AF episodes includes only episodes lasting >30 s. In the case of detected AF, the SRA service provides source of ECG rhythm strips which were reviewed by a trained stroke physician for confirmation of AF. SRA clinic has a 99% sensitivity and specificity compared with Holter ECG in the presence of manifest AF on ECG data. The final outcome of the traces analysis was sent from the central server to a secure email address and available to be read within few minutes. The clinical management as well as diagnostic procedures of all the patients with TIA, with and without AF, then followed routine practice of the treating physicians. Our team evaluates the risk of stroke and TIA at 6 months (in both phases) via the follow-up clinics during face-to-face interviews or through telephone calls. If the patient could not be contacted, a close relative or their family doctor is interviewed.

Patients

The following inclusion criteria had to be fulfilled in both the two phases of the study: (1) age ≥18 years old; (2) TIA diagnosis confirmed by a trained stroke physician; (3) no history of AF; (4) no AF on ECG performed in the TIA clinic; (5) no implanted pacemaker. Exclusion criteria were: (1) intracranial haemorrhage (2) TIA mimics[17] (migraine aura, seizures, syncope, peripheral vestibular disturbance, transient global amnesia, functional/anxiety disorder, amyloid spells, subarachnoid haemorrhage, structural brain lesion and paroxysmal symptoms due to demyelination). We extracted event characteristics, patient demographics, risk factors and medical history from medical records. Data of consecutive patients were extracted using a prespecified case report file that encompassed patient characteristics including age, vascular risk factors, laboratory results, relevant medical history and medications. CHA_2DS_2-Vasc score was calculated for each patient.

Definitions

TIA was defined as a brief episode of neurological dysfunction caused by focal brain or retinal ischaemia, with clinical symptoms typically lasting less than 1 hour, and without evidence of acute infarction.[18] By accepted convention, an episode lasting at least 30 s documented was considered as diagnostic for AF.[19] High blood pressure was defined as systolic pressure ≥140 mm Hg and/or diastolic pressure ≥90 mm Hg, use of antihypertensive medication, and/or previous diagnosis of high blood pressure. Carotid stenosis was defined according to the Trial of ORG 10172 in Acute Stroke Treatment[20] criteria as narrowing of the internal carotid artery lumen of ≥50% on carotid duplex ultrasound or angiography. Diabetes mellitus was defined as a history of diabetes that was confirmed in medical records, and/or use of insulin/oral hypoglycaemic agents, and/or random non-fasting blood glucose concentration ≥11.1 mmol/L. Hypercholesterolaemia was defined as fasting total cholesterol serum level ≥5.18 mmol/L (200 mg/dL), and/or fasting low-density lipoprotein cholesterol serum level of ≥4.14 mmol/L (160 mg/dL), and/or use of lipid-lowering medications. Coronary heart disease was defined by a history of acute myocardial infarction, or angina pectoris, or coronary artery bypass graft, or percutaneous coronary intervention. The duration of the cardiac monitoring was automatically provided (hours) with the routine and ACEM-Holter analysis. The time to initiate the cardiac monitoring was calculated as the total time (days) from the point of the assessment in TIA clinic to the point of activation of the cardiac monitoring.

Statistical analysis

Data analysis was conducted using SPSS (V.26.0, IBM). Characteristics of the study population were described using medians and IQR or mean and SD or numbers with percentages. P<0.05 was considered as significant. T-test or Mann-Whitney test were used to compare continuous variables. For categorical variables, a χ^2 or Fisher exact test was used to compare distributions.

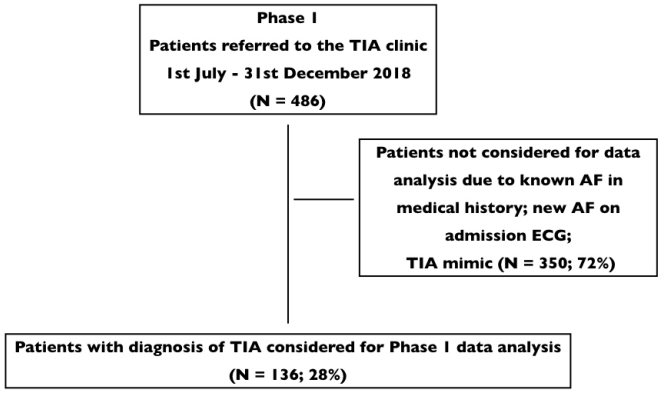

Figure 2 Patient recruitment in phase 1. AF, atrial fibrillation; TIA, transient ischaemic attack.

RESULTS

Between 1 July and 31 December 2018 (phase 1), 486 patients were referred to our TIA clinic with suspected TIA and 136 (28%) fulfilled the eligibility criteria (figure 2). During phase 2 (1 January to 30 June 2019) 468 patients with suspected TIA were referred to our service while 105 (22.4%) fulfilled eligibility criteria (figure 3).

Baseline characteristics of the two cohorts of patients are reported in table 1. Regarding the cardiac monitoring, two cohorts of patients did not show any statistically significant difference with regards to the duration of monitoring while the time interval to initiate the cardiac monitoring was significantly lower in phase 2 of the study compared with phase 1 (1 day (IQR 1–21) vs 62 days (IQR 13–111), p<0.001).

Detection of AF in the two phases of the study

Patients in phase 2 of the study had higher rate of newly detected AF than in the phase 1 cohort (9.52% vs 2.21%, p<0.001) (table 2). Unadjusted HRs for the rate of newly detected AF in phase 2 versus in phase 1 was 4.67 (95% CI 1.251 to 17.413, p=0.022).

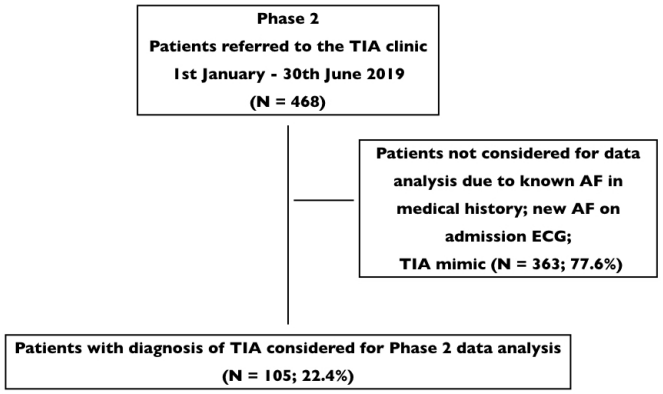

Figure 3 Patient recruitment in phase 2. AF, atrial fibrillation; TIA, transient Ischaemic attack.

Table 1 Baseline characteristics of the two cohorts of phase 1 and phase 2 patients

	Phase 1 (n=136)	Phase 2 (n=105)	P value
Demographics			
Age, y (median, IQR)	68; 48–88	69; 57–91	0.114
Male, sex	52 (38.2%)	52 (49.5%)	0.005
Medical history			
Hypertension	66 (48.5%)	61 (58.1%)	0.067
Diabetes mellitus	23 (16.9%)	17 (16.19%)	0.355
Hypercholesterolaemia	34 (25%)	30 (28.6%)	0.208
Coronary artery disease	17 (12.5%)	7 (6.7%)	0.068
Smoking	56 (41.2%)	50 (47.61%)	0.070
Previous TIA/stroke	21 (15.4%)	9 (12.9%)	0.296
Carotid stenosis	15 (11%)	17 (16.2%)	0.111
Peripheral vascular diseases	19 (13.97%)	15 (14.3%)	0.345
CHAD2DS2-VASc score (median, IQR)	2; 1–6	2; 1–6	0.456
Cardiac monitoring			
Duration of the cardiac monitoring (hours) (median, IQR)	23; 22–24	22; 14–30	0.541
Time to initiate the cardiac monitoring (days) (median, IQR)	62; 13–111	1; 1–21	<0.001

TIA, transient ischaemic attack.

Six-month risk of stroke/TIA

Patients in phase 1 showed a higher rate of stroke/TIA recurrence at 6 months (p=0.018) compared with the patients of phase 2 (online supplemental table 1). Unadjusted HRs for the rate of stroke/TIA recurrence at 6 months in phase 2 versus in phase 1 was 0.12 (95% CI 0.015 to 0.962, p=0.046).

DISCUSSION

Our study highlights the importance of early initiation of cardiac monitoring for improving AF detection after a TIA in an outpatient TIA service. Our results are also consistent with the findings of the systematic review and meta-analysis by Sposato *et al*.[6] The authors demonstrated that a mean time to the start of monitoring of 75 days was associated with a reduction in the detection rate of AF by over five times.

The second key finding of our study is that we observed that the 6-month risk of recurrent TIA/stroke fell significantly from phase 1 (7.4%) to phase 2 (1%). The earlier initiation of ACEM in phase 2 compared with the routine start of the Holter of phase 1 was associated with an almost 90% reduction in the risk of 6-month recurrent TIA/stroke. It is also noteworthy that in phase 1 of the study, 4 out of 10 (40%) of the recurrent stroke/TIA happened within 30 days after the first event. These findings are in line with previous studies. Lavallée *et al*[11] showed that a rapid assessment of patients with TIA reduced significantly the 90-day risk of stroke while Rothwell *et al*[12] documented an 80% reduction in the risk of early recurrent stroke in patients with TIA who received a rapid outpatient assessment.

Table 2 Detection of atrial fibrillation in phase 1 and phase 2 of the study

	Phase 1 (n=136)	Phase 2 (n=105)	P value
Absolute no. of detected cases	3	10	
Absolute frequency	2.21%	9.52%	<0.001

Overall, there are several technologies available for AF detection after a TIA or stroke that may vary significantly in their invasiveness and duration of monitoring.[21] There are several core components of the ACEM-Holter successful implementation. One aspect is that compared with the routine Holter, the ACEM-Holter has the advantage that can be performed at the stroke physician's office without sending the patient to the Cardiology Department. This is the main reason why the time interval to initiate the cardiac monitoring was significantly lower in phase 2 compared with phase 1 of the study. Another very important advantage is also that this system was able to analyse automatically the ECG-traces sent and to provide the result within few minutes with a 99% sensitivity and specificity compared with Holter ECG in the presence of manifest AF on ECG data.[15] This technology could be suited to be used in acute stroke patients that require bedside continuous electronically monitoring where the diagnosis of AF may require special attention and training by the stroke unit staff and can be often challenging or delayed. ACEM-Holter could be also adapted by local GPs in the primary-care where the screening for

AF in the population is time-consuming and can often be difficult to access. Although our analysis did not include patients with recurrent TIAs as these patients are usually admitted in our HASU, we believe that also this subgroup of patients could take advantage from an early initiation of ACEM as previously documented.[22]

Our study has several limitations. First, the prospective observational study design may have introduced selection biases. Another important limitation is that the two groups of patients were enrolled in two different time periods. As reported previously, diagnostic criteria and investigations were identical in both study periods and detailed documentation of all relevant baseline clinical characteristics were obtained in both study periods. However, we cannot completely exclude that there were other confounders that affected the rates of AF detected and stroke/TIA recurrence rate.

CONCLUSIONS

In conclusion, the present study suggests early initiation of ACEM in a rapid outpatient TIA clinic improves AF detection and is associated with a reduced risk of recurrent TIA/stroke. Further studies are required to confirm the enhanced rate of AF detected using ACEM

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Contributors LD served as quality improvement advisor and prepared initial draft of this manuscript, led the study and supervised implementation of changes. DK and SB played key role in physician's education and interventions. OS and SL data collection and analysis. LD assisted in statistical analysis. All authors contributed equally in the final approval of the manuscript. LD: guarantor.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study involves human participants and was approved by the UK Health Research Authority. Informed consent of subjects was not needed as the data collected for the study were information collected as part of the routine care and only deidentified data were used in the research.

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Supplemental Table 1. Rate of recurrent TIA/Stroke at 6 months after the index event.

	Phase 1 (n = 136)	**Phase 2 (n = 105)**	***p***
Recurrent TIA/Stroke	10 (7.4 %)	1 (1%)	0.018

TIA, Transient Ischemic Attack.