NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

Medical technology consultation document

KardiaMobile for detecting atrial fibrillation

NICE medical technologies guidance addresses specific technologies notified to NICE by companies. The 'case for adoption' is based on the claimed advantages of introducing the specific technology compared with current management of the condition. This case is reviewed against the evidence submitted and expert advice.

If the case for adopting the technology is supported, the specific recommendations are not intended to limit use of other relevant technologies that may offer similar advantages. If the technology is recommended for use in research, the recommendations are not intended to preclude the use of the technology but to identify further evidence which, after evaluation, could support a recommendation for wider adoption.

1 Recommendations

1.1 KardiaMobile shows promise for improved detection of atrial fibrillation and atrial fibrillation recurrence. However, there is not enough good-quality economic evidence to support the case for routine adoption in the NHS.

1.2 Research is recommended to address uncertainties about the cost impact of KardiaMobile for detecting atrial fibrillation and atrial fibrillation recurrence.

Find out details of required outcomes in further research.

Why the committee made these recommendations

KardiaMobile is an electrocardiogram (ECG)-monitoring device used to detect atrial fibrillation (AF). It comprises an ECG device, a software algorithm (KardiaMobile

app) that analyses the ECG data and provides a classification of rhythm including normal, possible AF, tachycardia, bradycardia or unclassified.

Clinical evidence shows that more people had their AF detected using the KardiaMobile single-lead device compared with standard care, which usually involves wearing a continuous ECG monitor such as a 24-hour Holter monitor.

Evidence suggests that using KardiaMobile is likely to be cost saving or cost neutral for detecting atrial fibrillation and atrial fibrillation recurrence. But further economic modelling is needed to address uncertainties and to help understand the cost impact of KardiaMobile compared with standard care. This model should focus on people presenting with palpitations and people who need to monitor AF recurrence where the evidence base for using the device is strongest.

2 The technology

Technology

2.1 KardiaMobile is a portable electrocardiogram (ECG) recorder for detecting atrial fibrillation (AF). It is available as a single-lead or 6-lead (KardiaMobile-6L) ECG recorder. The single-lead device has 2 electrodes on the top surface. The person places 2 fingers on each electrode to take their ECG. KardiaMobile-6L has 3 electrodes; 2 on the top surface and 1 on the bottom which is placed on the left leg. People must keep still and must keep touching the electrodes for at least 30 seconds for a complete recording to be taken.

2.2 KardiaMobile works with a compatible smart mobile device to run the Kardia app. While taking a reading, the ECG recording is sent wirelessly to the mobile device where it can be viewed in the app. The app shows the ECG trace and the classification as either normal, possible AF, tachycardia, bradycardia, or unclassified. Traces may also be classified as unreadable if the ECG data cannot be interpreted because of possible interference. ECG data can be saved as a pdf file and emailed to healthcare professionals.

Innovative aspects

2.3 KardiaMobile is easy to use, it is compact and can be used anywhere, at any time of the day, to record an ECG. ECG recordings can be made available to healthcare professionals as soon as they are taken rather than at the end of a specified monitoring period.

Intended use

2.4 The KardiaMobile heart monitor and Kardia app is intended for adults to detect abnormal heart rhythms. This guidance focuses on using KardiaMobile for detecting AF in adults referred for ECG monitoring. KardiaMobile would be prescribed by a healthcare professional for people who are experiencing arrhythmia symptoms. The healthcare professional will advise on the frequency and length of use. The instructions for use state that all interpretations of ECG recordings should be reviewed by a healthcare professional and used to support clinical decision making.

Relevant pathway

2.5 NICE's guideline on atrial fibrillation recommends that people with suspected AF have manual pulse palpations to detect an irregular pulse. If an irregular pulse is then detected, an ECG such as a 12-lead ECG is done. If an irregular pulse is then undetected by a 12-lead ECG recording an ambulatory monitor, event record or other ECG monitors should be done whether or not the person has symptoms.

Costs

2.6 The cost of single-lead KardiaMobile is £82.50 (excluding VAT) The Kardia app is free of cost.

For more details, see the website for KardiaMobile.

3 Evidence

Clinical evidence

The main clinical evidence comprises 27 studies including 5 randomised controlled trials

3.1 There were 27 studies relevant to the decision problem in the scope:

- 5 randomised controlled trials (RCTs)
- 7 diagnostic accuracy studies
- 1 case-control study
- 13 single-arm observational studies
- 1 case report.

3.2 Of the 27 included studies, 16 studies were peer reviewed, including 4 UK studies (Bray et al. 2021; Reed et al. 2021; Reed et al. 2019; Dimarco et al. 2018), one of which is a RCT (Reed et al. 2019). The included studies covered 6 population groups:

- People with palpitations.
- People with a history of atrial fibrillation (AF), who have had treatment (ablation, cardioversion, or medical therapy) to restore sinus rhythm and used KardiaMobile to identify recurrence.
- People with diagnosed AF to assess AF burden.
- People with transient AF after surgery or hospitalisation who reverted back to sinus rhythm before discharge and used KardiaMobile to identify recurrence.
- People after stroke or transient ischaemic attack who were monitored using KardiaMobile.
- Mixed population including people with known or suspected AF.

All published evidence is on the single-lead KardiaMobile device.

For full details of the clinical evidence, see section 4 of the assessment report.

Evidence shows that monitoring with KardiaMobile increases AF detection

3.3 Three RCTs including 1 UK trial (Koh et al. 2021; Goldenthal et al. 2019; Reed et al. 2019) found that significantly more people in the KardiaMobile monitored group had AF detected compared with those who had standard care, which included 24-hour Holter monitoring. This was supported by the results from an observational study (Yan et al. 2020).

Evidence suggests that the KardiaMobile algorithm has a high diagnostic accuracy per electrocardiogram (ECG) recording

3.4 Four peer reviewed studies (Hermans et al. 2021; Selder et al. 2019; William et al. 2018; Lowres et al. 2016) reported on diagnostic accuracy of AF detection using the KardiaMobile algorithm compared with clinical interpretation of the KardiaMobile ECG as the reference standard. Its sensitivity ranged between 92% and 99% per recorded ECG, with a specificity between 92% and 98%. However, the external assessment centre (EAC) highlighted that diagnostic accuracy was reported on a per ECG recording and not a per person basis. Also, these 4 studies had 4 different patient populations with a pre-test probability of AF between 4.8% and 35.6%.

Evidence shows that using KardiaMobile reduces time to AF detection but there is no direct evidence for clinical outcomes after AF diagnosis

3.5 Reed et al. 2019 showed that people using KardiaMobile had their symptomatic cardiac arrhythmia detected significantly earlier than those having standard care (9.9 days compared with 48.0 days, p=0.0004). This finding was supported by 1 observational study (Yan et al. 2020) which also reported that KardiaMobile significantly reduced the time to AF detection when compared with standard care. There was no direct published evidence to show that using KardiaMobile improves clinical outcomes (such as reduction in stroke) after a diagnosis of AF.

KardiaMobile is easy to use and is associated with an improvement in quality of life

3.6 The evidence from 12 studies and a patient survey reported that KardiaMobile was easier to use compared with other ECG monitors such as Holter monitors. People felt that KardiaMobile would be useful in self-monitoring at home and improving their ability to access the care they needed. Two RCTs (Caceres et al. 2020 and Guhl et al. 2020) showed that people who used KardiaMobile had a significant improvement in AF-specific quality of life scores compared with people in the control groups. The EAC noted that both trials used additional interventions, and the effect of KardiaMobile alone on quality of life may be difficult to interpret.

The rate of unclassified ECG outputs varied in the studies but is falling because of software updates

3.7 Evidence reported that there were a proportion of ECG traces that do not fit the current KardiaMobile algorithm classifications, ranging from 9.6% to 27.6%. These outputs are presented as unclassified. However, software updates are improving the classification algorithm, and the number of unclassified outputs is reducing. Also, around 0.6% to 1.9% of KardiaMobile outputs were unreadable. This often happens when an ECG trace has interference and cannot be interpreted by the Kardia app, however a proportion of these can be interpreted by a clinician.

Cost evidence

Published cost evidence includes 2 UK studies representing NHS costs

3.8 Three published studies reported the economic impact of KardiaMobile

- a cost-effectiveness analysis done alongside a UK RCT compared the cost per symptomatic rhythm diagnosis using KardiaMobile in addition to standard care with standard care alone (Reed et al. 2019)
- a UK budget impact analysis (YHEC et al. 2018)
- a US single-arm study estimated the cost saving using data from a patient survey (Praus et al. 2021).

All studies reported that KardiaMobile was cost saving. Two studies reported that the main driver for the saving was a reduction in healthcare appointments.

The company presented a cost model showing that monitoring with KardiaMobile saves between £320 and £382 per person over 5 years

3.9 The company developed a de novo model comparing KardiaMobile with Holter monitoring and the Zio patch. The model included people aged 64 or above with known or suspected AF who were referred for ambulatory ECG monitoring in a secondary care setting. The model assessed the costs associated with diagnosing and managing AF. Overall, the company's base case showed that using KardiaMobile could save between £320 and £380 per person over 5 years because of the cost of the technology, reductions in repeat testing, referrals to secondary care, and stroke events.

For full details of the cost evidence, see section 9 of the assessment report.

The EAC was unable to validate the company model limiting the certainty in the results presented

3.10 The EAC was unable to validate the company's model and highlighted limitations and errors in some of the parameters and assumptions used. The complexity of the model meant that inconsistencies could not be investigated and corrected. There was a lack of robust evidence to support the need for such complex time dependencies in the diagnostic phase of the model, and this approach required several additional assumptions. The EAC considered the diagnosis phase could have been modelled more simply. Overall, the EAC considered the model to be overly complex, not transparent and not verifiable. It also did not agree with underlying structural assumptions, parameter choice or their implementation in the model.

The EAC's cost calculator finds KardiaMobile to be cost saving in some scenarios

3.11 The EAC developed a simple cost calculator to explore the expected costs of using KardiaMobile to detect and treat AF over a 1-year time horizon. The cost calculator is a decision tree based on AF detection rates and risk of stroke in treated and untreated AF. The EAC presented 6 scenarios that were informed by the published comparative studies, with varying populations, definition of standard care and AF detection rates (Hermans et al. 2021, Narasimha et al. 2018, Koh et al. 2021, Reed et al. 2019, Goldenthal et al. 2019, Hickey et al. 2017). KardiaMobile was found to be cost saving compared with Holter or external loop recording in 3 scenarios, with a saving of £144 to £490 per person. But KardiaMobile incurred an additional £32 per person when used in addition to standard care (including Holter monitoring).

4 Committee discussion

Clinical-effectiveness overview

KardiaMobile single-lead device is associated with improved detection of atrial fibrillation

4.1 The committee noted considerable evidence from 6 comparative studies, including 3 RCTs, showed improved atrial fibrillation (AF) detection using the single-lead KardiaMobile. The clinical experts agreed that monitoring with KardiaMobile could increase AF detection because it could record an AF event whenever symptoms are presented. The committee agreed that there is a strong case for patient benefit.

KardiaMobile single-lead device is an option for detecting AF but there is no evidence on the 6-lead device

4.2 The committee noted that all the evidence on the clinical effectiveness of KardiaMobile was on the single-lead device. It was advised that the single-lead device is commonly used in clinical practice to detect AF, and the use of the 6-lead device is limited in the NHS. The clinical experts

agreed that the 6-lead device had no additional benefit for detecting AF but it could be helpful to detect other arrhythmia. The committee concluded there was no additional benefit from using the 6-lead device compared with the single lead KardiaMobile for AF detection.

KardiaMobile is an easy-to-use technology and its accessibility means it is well suited for ambulatory monitoring

4.3 Evidence from published studies and patient experts shows the KardiaMobile device is easier to use compared with other electrocardiogram (ECG) monitors such as the Holter monitor. People who had experience of using KardiaMobile found the device to be accessible at symptom onset and allowed improved access to care when needed. The experts noted that age is not a barrier preventing people from using KardiaMobile. It has been well accepted across people in different age groups if they have a compatible mobile device. The committee concluded that KardiaMobile is a convenient device that people can use at home to monitor their heart rhythms.

Evidence supports the use of KardiaMobile for improved detection of atrial fibrillation and atrial fibrillation recurrence, especially in people with palpitations and who need to monitor AF recurrence

4.4 The clinical evidence supported the use of KardiaMobile in 6 broad populations groups (see section 3.1). The EAC advised the evidence base was strongest in people with undiagnosed palpitations and people with a history of AF who need to monitor their AF recurrence. The experts noted that, in clinical practice, KardiaMobile has been most commonly used in these 2 groups. The committee concluded that the population groups in the evidence base reflected use of the KardiaMobile device in a wide range of relevant clinical contexts but it considered the most persuasive clinical cases were people with undiagnosed palpitations and people with a history of AF who need to monitor their AF recurrence.

Additional information about the long-term clinical consequences of using KardiaMobile would be valuable

4.5 The clinical experts advised that AF is a chronic condition. After AF is diagnosed, people are likely to be on medications such as anticoagulation or anti-arrhythmia to reduce the risk of stroke and control symptoms for a long time. The experts noted that KardiaMobile could improve medication management; for instance, some medications can only be used when normal heart rhythm is restored. However, no direct evidence was available on the clinical benefits of KardiaMobile after diagnosis of AF; for example the association between the early AF detection and reduction in longer-term outcomes such as stroke events. The committee understood the limitations of the evidence base and concluded that more research on the long-term clinical outcomes of using KardiaMobile would be valuable.

NHS considerations overview

Patient selection will improve the care pathway and should be guided by clinical judgement

4.6 Patient selection is important and should be guided by clinical judgement. The clinical experts emphasised that devices need to be offered to people on an individual basis guided by clinical assessment of individual circumstances. Key factors to consider include: risk of developing AF, age, comorbidities, and the availability of primary and secondary care resources to interpret ECG traces. Furthermore, other factors such as the compatibility of mobile devices and patient preference also need to be considered. They noted that widespread use of KardiaMobile in the NHS without careful patient selection may place extra demand on local services. The committee concluded that healthcare professionals should assess individuals and indications when considering whether to prescribe KardiaMobile.

KardiaMobile is not intended to be used for diagnosing AF and its outputs should be reviewed by a healthcare professional

4.7 The committee noted that one of KardiaMobile's advantages over some other technologies is that it is a portable device that provides real-time ECG traces and heart rhythm classification. Despite this, the external assessment centre (EAC) confirmed that clinical interpretation of all recorded ECGs is needed, in line with the device instructions for use, to limit the effect of false negative and false positive results. The clinical experts added that expertise in interpreting ECG traces is essential to ensure the accuracy of AF diagnosis. Also, the experts added that a considerable proportion of unreadable and unclassified ECG recordings would be interpretable by experienced healthcare professionals to inform clinical decision making. The committee concluded that ECG data generated by KardiaMobile should be reviewed by an experienced healthcare professional before a diagnosis is made.

Training is important to minimise unreadable ECG recordings when using KardiaMobile

4.8 The clinical experts highlighted the issue of unreadable ECG traces. They explained that the way people used the device is likely to affect the quality of ECG recordings. In clinical practice, healthcare professionals often provide support for people to set up the device, allowing them to also advise on effective use. There are also self-help videos that explain how to use the device. The clinical experts noted that a lack of experience using the device may lead to unreadable ECG recordings. The committee concluded that training is important to make sure people use the device correctly and minimise possible interference while taking the recording.

Cost-modelling overview

The company's cost model estimated KardiaMobile to be cost saving compared with other ECG monitors but could not be validated by the EAC

4.9 The committee noted that the results from the company's cost model showed that KardiaMobile is cost saving compared with Holter monitor

and the Zio patch over a 5-year time horizon. The committee noted however, that the EAC could not validate the company's model and did not replicate it because the EAC considered that the model structure, underlying assumptions, and parameters did not reflect the care pathway. The committee concluded that the cost savings presented in the company model are uncertain.

The EAC's cost calculator does not fully capture the cost impact of KardiaMobile

4.10 The committee noted that the EAC presented a cost calculator to further explore the cost consequences of using KardiaMobile to detect AF, based on the 6 published comparative clinical studies. The cost calculator results suggested that KardiaMobile could be cost saving in some scenarios over a 1-year time horizon. The potential savings were driven by the increased rate of detection of AF with KardiaMobile, leading to a reduction in the number of strokes. The EAC acknowledged the limitations of its cost calculator approach including a small selection of studies, comparators being restricted by the selected studies and without considering the effect of novel oral anticoagulants on stroke risk. The committee concluded that in the absence of a robust cost model the cost impact of using KardiaMobile is uncertain and it was therefore not possible to recommend for routine adoption in the NHS.

Further research

Further evidence on the cost impact of KardiaMobile for atrial fibrillation detection compared with standard care is needed

4.11 The single-lead KardiaMobile shows promise for improving atrial fibrillation detection, but further research is needed to evaluate the cost impact compared with standard care in the NHS. The committee agreed that further economic evidence based on robust modelling would help to better understand the cost impact of KardiaMobile for detecting atrial fibrillation and atrial fibrillation recurrence. This should include an economic model based on the evidence base where KardiaMobile shows

greatest promise, including people presenting with palpitations and people who need to monitor AF recurrence.

Committee members and NICE project team

Committee members

This topic was considered by NICE's medical technology advisory committee, which is a standing advisory committee of NICE.

Committee members are asked to declare any interests in the technology to be appraised. If it is considered there is a conflict of interest, the member is excluded from participating further in that evaluation.

The minutes of the medical technology advisory committee, which include the names of the members who attended and their declarations of interests, are posted on the NICE website.

NICE project team

Each medical technologies guidance topic is assigned to a team consisting of 1 or more technical analysts (who act as technical leads for the topic), a technical adviser and a project manager.

YingYing Wang, Dionne Bowie
Health technology assessment analysts

Lizzy Latimer
Health technology assessment adviser

Victoria Fitton
Project manager

ISBN: [to be added at publication]