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A simple adaptation of a handheld ECG recorder to obtain chest lead equivalents

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ABSTRACT

Hand held ECG recorders are transforming the way we detect and diagnose heart rhythm disorders. The Kardia 6 L was launched in 2019 to detect and diagnose heart rhythm disorders recording a six lead (limb lead) ECG. Recording and analysis of precordial leads are currently not supported by the Kardia 6 L. In this study we aim to assess if reliable chest lead data can be obtained using a simple modification to the recording system.

Introduction

Handheld ECG recorders compatible with mobile phones have transformed the recording of cardiac rhythm disorders [1]. The Kardia 6 L (AliveCor Inc., Mountain View, CA 94041, US) was launched in November 2019 and can record a standard six, limb-lead, ECG. The Kardia 6 L (K6L) is a small battery driven handheld device (9.0 cm × 3.0 cm × 0.72 cm) (Fig. 1). The K6L has three stainless steel electrode contacts, two on the top surface (for left, right thumbs) and one on the lower surface (for left lower limb). The device can record leads I, II, III, aVR, aVL and aVF simultaneously. The K6L device works together with any standard IOS or Android phone. ECGs recorded from the K6L are wirelessly transmitted using a Bluetooth low energy communication to a smartphone where the augmented leads are calculated, and the results are displayed.

The COVID-19 pandemic has affected medical services worldwide. The virus is highly infectious and medical equipment that is brought into contact with patients admitted to hospital who may be infected requires thorough cleaning. Standard 12-lead ECG cables are generally not disposable and can be difficult to clean. The K6L in contrast is easy to clean and readily available at the point of care. The addition of chest lead data from a modified adaptation of this device would provide additional data relevant in the management of cardiac conditions, for example, bundle branch block, ST segment shift reflecting ischaemia and regional repolarisation abnormalities. These changes may not be picked up on the limb leads alone. An example of the flexibility and adaptability offered by the K6L recorder is demonstrated by the ability to monitor QT interval in COVID-19 patients [2]. Acquisition of data from the 6 L ECG is easy, and the device can be used by members of the public.

Moreover, handheld ECG recorders can provide cardiac rhythm diagnosis at low cost in primary care and over-stretched hospital environments. They also offer a very viable solution to improve health care services in widely underserved rural areas worldwide [3].

In this pilot study, we examined if a simple modification to the K6L that allows the acquisition of additional chest lead data would enhance the function of this compact ECG recorder.

Methods

We prospectively recruited patients from the cardiac wards at the Leeds General Infirmary, Leeds, UK. Consecutive patients were studied with the aim of capturing a range of common ECG appearances (including atrial fibrillation, ST elevation, bundle branch block). Patients had been admitted for a variety of reasons, including non-cardiac chest pain, acute coronary syndrome, atrial fibrillation and heart failure.

The study was reviewed by the Research and Innovation Department at Leeds Teaching Hospitals NHS Trust and approved as a Service Evaluation Project.

A standard 12 lead ECG was obtained with a MAC 550 (GE Healthcare, WI, USA). A 6 lead ECG was acquired next using the K6L, which provides the equivalent of Leads I, II, III, aVF, aVL, and aVR. The filter settings for the 12 lead were 0.05-100 Hz and 0.05 to 40 Hz for the Kardia. The sampling rate stated by the manufacturer was 300/s. The dynamic range and resolution of the system (16 bit at 10 mV, thus <1 μV).

The chest lead data was acquired as follows: A standard ECG electrode (Skintact; Leonhard Land, Austria) was attached to the left leg over the medial malleolus after ensuring that the skin was cleaned with isopropyl alcohol wipes and excess hair had been removed.

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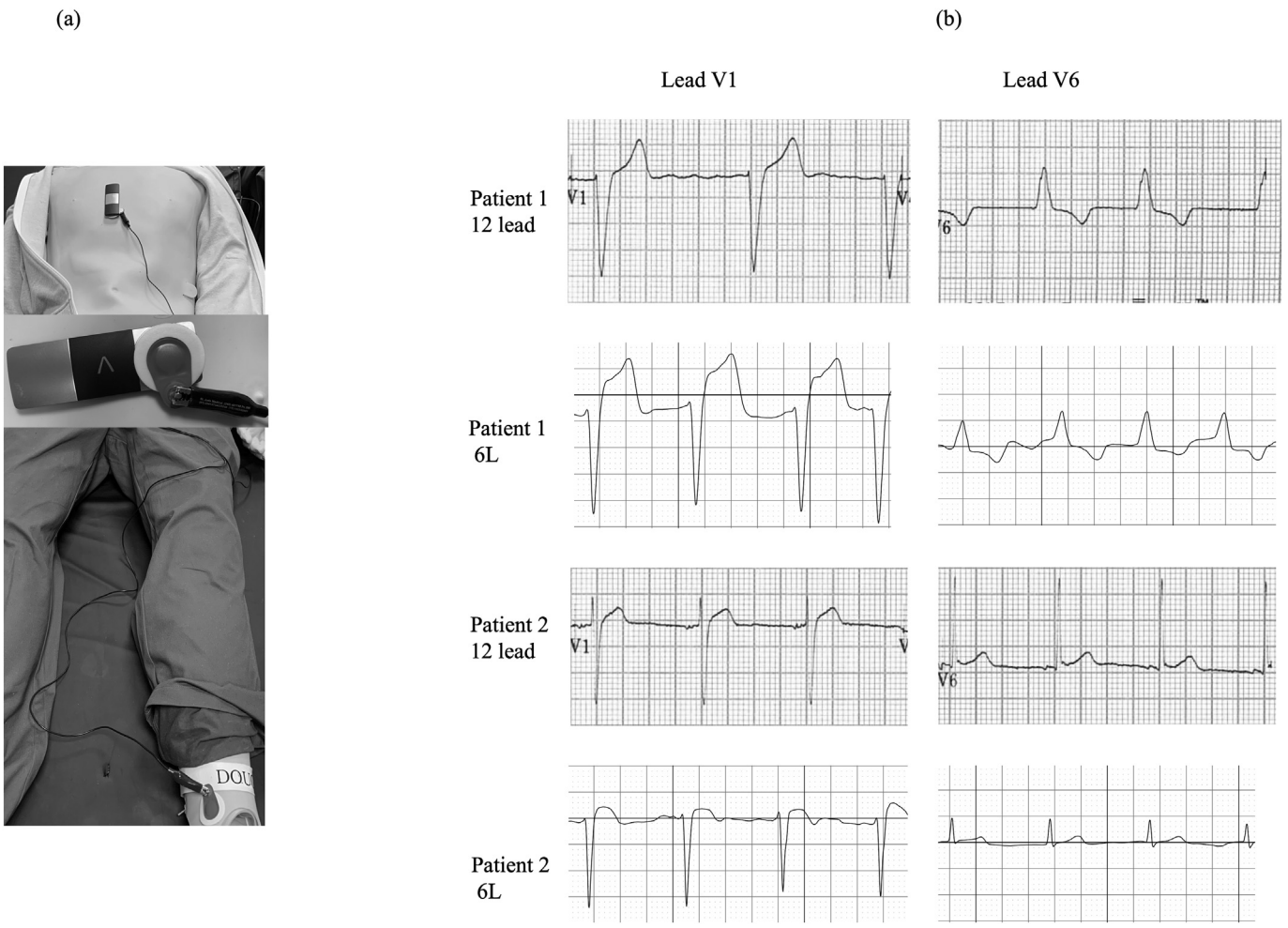

Fig. 1. (a) adaptation of 6L device for recording chest leads (b) validation of equivalent V1, V6 against standard 12 lead ECG. In each example the scale is 10mm/mV and 25 mm/ms.

Another ECG electrode was attached to the electrode on the right side of the "Λ" sign of Kardia. The left leg electrode was connected to the ECG electrode attached to the Kardia using a pacing threshold cable with small crocodile clips at either end. The electrode on the left hand side of the "Λ" sign on the Kardia was held in contact with the chest (using isopropyl alcohol swabs if needed to improve contact) in the standard V1 and V6 positions. For consistency the Kardia was orientated in the vertical axis (chest electrode superior to left leg electrode). Rhythm strips were recorded sequentially in each of these six positions for up to 30 s ensuring that patient movement was nil or minimal and that stable manual pressure was applied to the K6L on the chest (Fig. 1b). The 12 lead ECG was recorded first, followed by the Kardia recordings which were initiated immediately (i.e. within a few seconds after the 12 lead ECG was collected).

Two cardiac electrophysiologists manually analysed leads V1 and V6 (PR interval, QRS duration, QT interval, subjective similarity) from the standard 12 lead ECG and compared it to the equivalent V1 and V6 recordings from the K6L. The quality (clear baseline and absence of artefact) and QRS match were documented as good, average or poor.

Results

We enrolled and completed the study protocol in 21 unselected patients who had been admitted to the cardiac wards.

It was possible to calculate the PR interval and axis on the 6 L six lead ECG in all patients. The diagnosis of atrial fibrillation was correctly made in 100%.

The quality of the ECG in V1 and V6 equivalents was good (91% recordings), with low noise (<0.1 mV). In 72% of the recordings of V1 and V6 the QRS waveform was subjectively similar (equivalent to a good pace match) between the 12 lead and K6L (Fig. 1b).

QRS duration measurement was not possible in one patient in V1 but possible in all in V6. The Pearson coefficient of correlation was 0.936 ($p < 0.0001$) and 0.844 ($p < 0.0001$) for QRS duration in V1 and V6 respectively.

QT analysis was performed in 19 of 21 (90.5%) patients in V1 (one not possible on 12 lead) and 16 in V6. The respective coefficients of correlation were 0.958 ($p < 0.0001$) and 0.892 ($p < 0.0001$).

Discussion

This study demonstrates how a simple modification can enable a hand held ECG recorder to obtain accurate chest lead data necessary for diagnosis of several conditions and conduction disorders e.g. left bundle branch block potentially indicating a diagnosis of myocardial infarction. Connectivity via Bluetooth avoids the need to bring multiple cables and relatively bulky ECG recorders close to the patient. This is pertinent in those patients with infectious diseases such as COVID-19. In addition, this technique extends the utility of a handheld, smartphone based recorder in healthcare systems where standard ECG monitors are less readily accessible. The device is portable, and the modification is very simple allowing healthcare professionals to perform ECGs with a very brief period of training. The nurse performing the ECGs had not used the 6 L before, but was able to perform the modified

ECG easily. The equipment required to perform the ECG apart from the 6 L were cheap, disposable and readily available in any healthcare setting. In addition, as the data is recorded electronically, it can be easily and instantly shared securely with other health care professionals for interpretation and/or specialist opinion.

In this pilot study we show that it is feasible to record chest leads with a simple adaptation of the Kardia device. However, further work in the form of a larger study is required to validate this modification before we can safely accept this for standard clinical use.

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Author statement

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Data curation : LL, NA.
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Declaration of Competing Interest

No authors have anything to disclose specific to this manuscript.

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