

Usefulness of a Single-lead Electrocardiographic Recording System and Wireless Transmission During the COVID-19 Pandemic

Utilidad de un sistema de registro de una derivación electrocardiográfica y transmisión inalámbrica durante la pandemia por COVID-19

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ABSTRACT

Background: Some therapies used for COVID-19 can prolong the QT interval and produce severe arrhythmias. QT interval measured from a standard electrocardiogram (ECG) requires additional personnel and risk of infection. Novel technologies to obtain an ECG connected to smartphones provide an alternative for the evaluation of corrected QT interval (QTc).

Objective: The aim of this study was to evaluate the feasibility of using a single-lead ECG device to measure the QT interval in patients with suspected or confirmed COVID-19 before receiving treatment with drugs that can prolong the QT interval.

Methods: The ECG was obtained with a KardiaMobile (KM) device and transmitted to a smartphone. The ECG recordings were saved as pdf files and electronically submitted to the electrophysiology section which centralized the reception and assessed the measured QT and QTc intervals.

Results: A total of 31 patients (mean age 61 years, range 20-95 years) with suspected COVID-19 enrolled for treatment with hydroxychloroquine, azithromycin, ritonavir or lopinavir were analyzed. The recordings could be read in all the cases and had to be repeated in two cases. The mean value of the QTc interval was 423 ms (range 380-457 ms) in men and 439 ms (range 391-540 ms) in women. The response time since the ECG recording was submitted for analysis was 11 min (range 1-155).

Conclusions: The QTc interval could be measured from ECG recordings obtained with KM devices connected to a smartphone and transmitted to a centralized reading center in all patients.

Key Words: Coronavirus Infections - COVID-19 - Arrhythmias, Cardiac - Smartphone - Mobile Applications - Electrocardiography, Ambulatory/instrumentation

RESUMEN

Introducción: Se ha comunicado que algunos tratamientos utilizados para la infección por COVID-19 pueden ocasionar alteraciones del intervalo QT y arritmias graves. La medición por electrocardiograma (ECG) convencional requiere personal adicional y riesgo de contagio. Nuevas tecnologías para obtención de un ECG conectados a teléfonos inteligentes (*smartphones*) proporcionan una alternativa para evaluación del QTc.

Objetivo: El objetivo fue evaluar la factibilidad de un dispositivo para registro electrocardiográfico de un canal, para la medición del intervalo QT en pacientes con sospecha o confirmación de infección por COVID-19, antes de recibir drogas que prolongan el intervalo QT.

Material y métodos: Se obtuvieron registros de ECG con un dispositivo Kardia Mobile (KM) con transmisión a un *smartphone*. La sección de electrofisiología cardíaca centralizó la recepción por medio electrónico de los ECG en formato de archivo pdf y realizó las mediciones de los intervalos QTm y QTc.

Resultados: Se estudiaron 31 pacientes, edad promedio 61 años (rango 20-95 años), sospechosos de presentar infección por COVID-19 enrolados para tratamiento con hidroxiclороquina, azitromicina, ritonavir y lopinavir. Los registros pudieron ser leídos en todos los casos, y debieron repetirse en dos casos. Los valores del intervalo QTc promedio en varones y mujeres fue 423 mseg (rango 380-457 ms) y 439 mseg (rango 391-540 mseg), respectivamente. El tiempo de respuesta desde el envío del ECG al grupo de análisis fue 11 min (rango 1-155).

Conclusiones: Los registros ECG obtenidos con dispositivos KM, para transmisión a un *smartphone* a un grupo central de lectura, permitieron la medición del intervalo QTc en todos los pacientes.

Palabras Claves: Infección por Coronavirus - COVID-19 - Arritmias cardíacas - Teléfono Inteligente - Aplicaciones Móviles - Electrocardiografía Ambulatoria/instrumentación

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Abbreviations

NICE National Institute for Health and Care Excellence
QTc Corrected QT

PPE Personal protective equipment
SP Smartphones

INTRODUCTION

Some therapies currently implemented in the medical community for the treatment of COVID-19 pneumonia include hydroxychloroquine, azithromycin, ritonavir or lopinavir. These drugs may be associated with QT interval prolongation and potentially fatal ventricular arrhythmias, so a strict monitoring of these adverse effects during treatment is recommended. (1, 2)

In a complex situation with health system overload due to a pandemic, performing a 12-lead ECG turns out to be a complicated task due to the participation of dedicated staff plus transportation and disinfection of the electrocardiograph and its leads. The ability of the virus to survive in fomites for several hours or days is one of the factors that makes the disease highly contagious. We have proposed the use of portable single-lead electrocardiographic recording devices to protect health care professionals, minimize risks and reduce the workload of doctors who are on the front line of care.

The aim of this study was to evaluate the feasibility of using a single-lead electrocardiographic device with wireless connection to a smartphone for the centralized measurement of the QT interval in patients with suspected or confirmed COVID-19 before receiving treatment with drugs that can prolong the QT interval.

METHODS

A portable single-lead electrocardiographic KardiaMobile (KM) device (AliveCor Inc., San Francisco, CA, USA) was used. It weighs 18 g, has a small size of 8.2 cm x 3.2 cm x 0.35 cm, is available for iOS and Android platforms and can connect wirelessly to smartphones via Bluetooth. The device consists of two conducting plates (two 3 cm x 3 cm stainless steel electrodes) to make contact with the patient's fingers and record a bipolar lead (Figure 1). It has been approved by the National Institute for Health and Care Excellence (NICE) and has proved to be useful for the assessment of ECG intervals in patients taking drugs that prolong the QT interval, such as dofetilide. (3, 4)

The study group was made up of consecutive patients prospectively included in our hospital for pneumonia and suspected or confirmed COVID-19 before starting treatment with hydroxychloroquine and azithromycin. All health care professionals unfamiliar with the management of the system were trained in operating the KM device. All electrocardiographic recordings were taken on admission and stored in the personal mobile phone of each coordinating physician using the specific tool for iOS or Android systems. The recordings were then submitted to the staff of the electrophysiology section of our institution as PDF files to calculate the corrected QT interval (QTc). An algorithm specifically developed for this purpose considered the baseline measurements of QTc from the KM recording, and the Tisdale score was



Fig. 1. Portable single-lead ECG KardiaMobile device (AliveCor Inc., San Francisco, CA, USA).

calculated to identify the individual risk of prolonged QT interval during hospitalization. (5) A specific software was used for digital measurement (EP Calipers). The QTc interval was determined with Bazett's formula. When QRS duration was greater than 120 milliseconds (ms), the Bogossian formula was applied by subtracting 50% of QRS duration to the value found with Bazett's formula. (6) Two blinded investigators compared the QTc measured with KM with the one obtained from a standard ECG in a control group of 12 patients hospitalized for other conditions.

Statistical analysis

Data were described as mean and standard deviation or median and range according to their distribution. A linear regression analysis was performed calculating Pearson's correlation coefficient in the control group. All the statistical calculations were performed using IBM SPSS 20.0 statistical package for Macintosh (IBM Corp., Armonk, NY, USA).

Ethical considerations

The head of the Department of Cardiology was informed of our interest in carrying out this study and his authorization was requested. The study was performed following the Guidelines for Good Clinical Practice and current legal regulations.

RESULTS

In the control group of 12 patients the QTc interval was measured in the 12-lead ECG (426 ± 43 ms) and KM recordings (434 ± 52 ms) (Figure 2). A very good correlation was observed between both measurements (R^2 coefficient 0.905, Figure 3).

Between April 2, 2020 and May 9, 2020, 31 ECG recordings were obtained from 12 female and 19 male patients with mean age of 61 years (range 20-95 years). The recordings were optimal and allowed the meas-

urement of the QT interval and QTc calculation in all the patients. In two patients an additional recording was necessary, placing the KM device on the precordium at the level of V1-V2 leads to confirm the previous measurement (Figure 4). Twenty-nine patients presented sinus rhythm with mean PR interval of 144 ms (range 120-180 ms). One patient had atrial fibrillation and another presented AV junctional rhythm

on admission. Narrow QRS was present in 25 patients (90 ms, range 80-120 ms), while wide QRS occurred in six patients (mean 153.3 ms, range 140-160 ms). Mean heart rate was 90.8 beats per minute. The QTc interval was within normal range to receive and continue treatment in 30 patients, and only one patient presented prolonged QTc of 540 ms. In this patient, after analyzing the risk-benefit ratio of the treatment,

Fig. 2. A) Measurement of prolonged QTc interval in lead I in a surface ECG recording. B) Measurement of the QTc interval in the same patient using the KardiaMobile device.

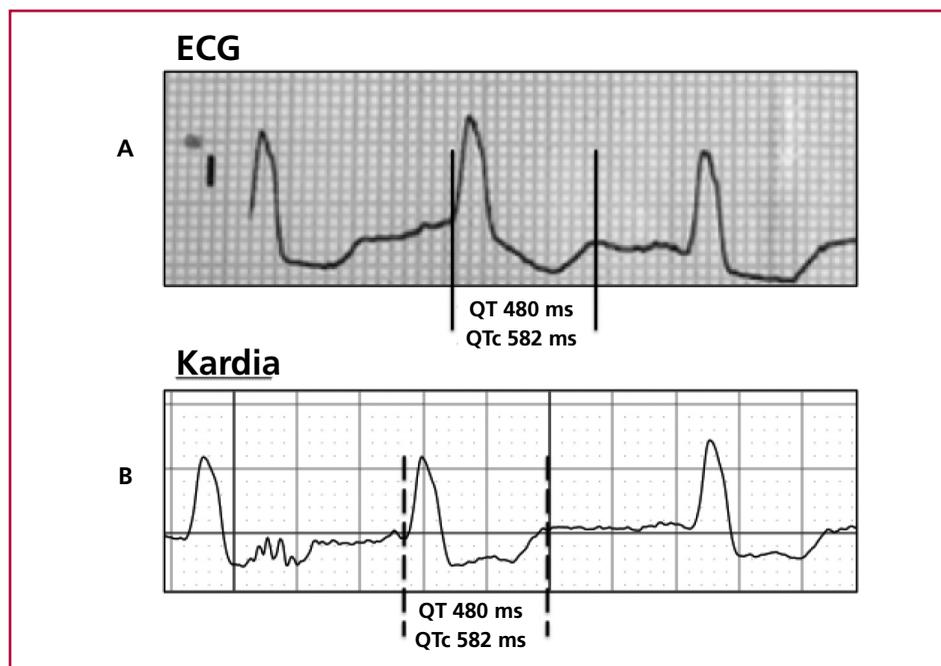
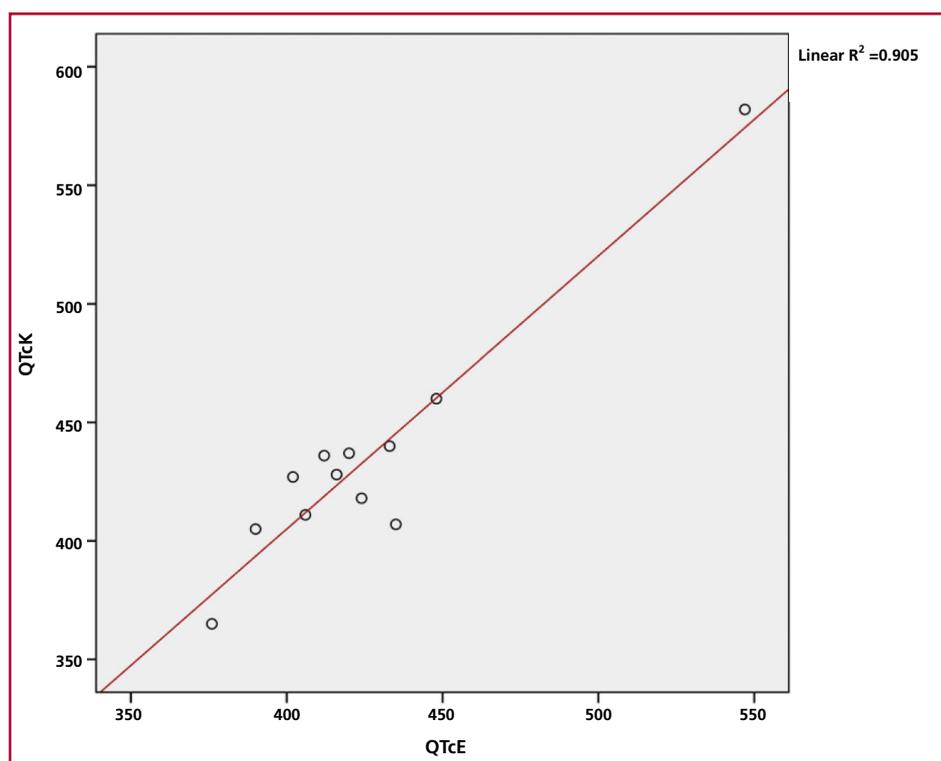


Fig. 3. Correlation between QTc measured by ECG (QTcE) and QTc measured by KardiaMobile (QTcK). Scatter plot.



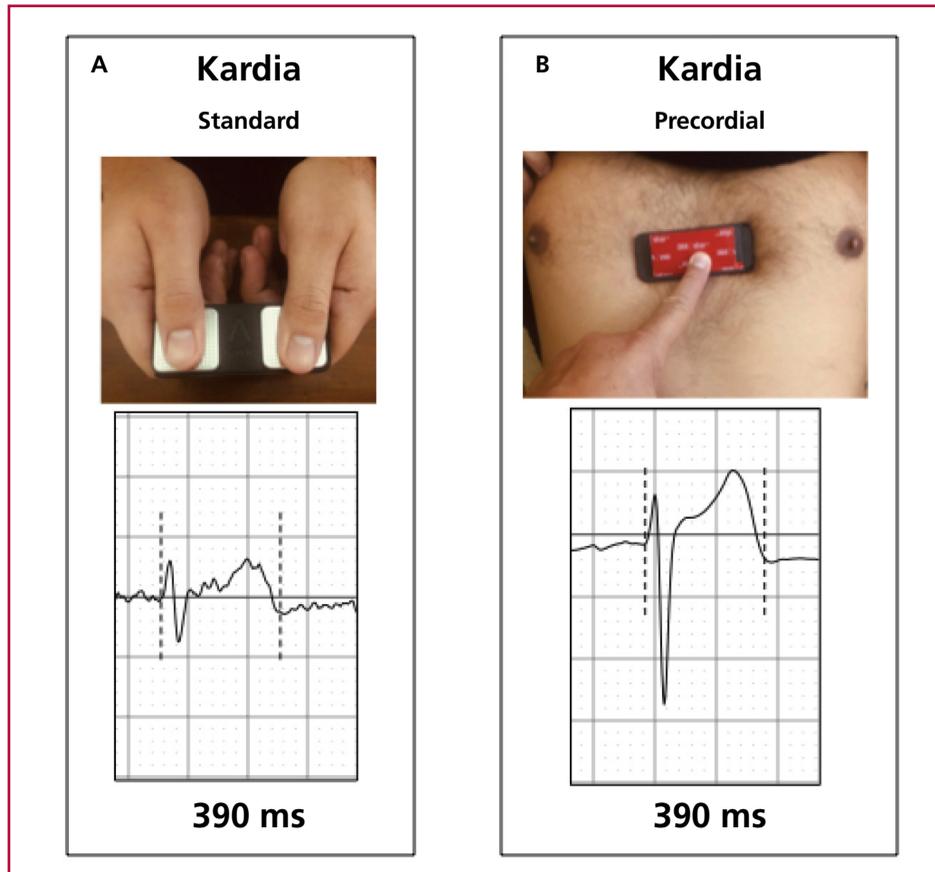


Fig. 4. A) Standard recording obtained with a KardiaMobile device. B) ECG recording in V1-V2 position using the KardiaMobile device to measure the QT interval in the same patient.

the drugs were not administered. The mean value of the QTc interval was 423 ms (range 380-457 ms) in men and 439 ms (range 391-540 ms) in women. The median response time since the ECG recording was submitted for analysis was 11 min.

DISCUSSION

The findings of our study show that measurement of the QTc interval using a KM device is feasible and avoids the involvement of additional health care personnel and supplementary equipment with the logical benefits in a highly contagious disease.

The advantage of the KM system is its simplicity, so it can be used by the same staff that takes the patient's vital signs every day, thus avoiding the involvement of additional personnel. We also found that centralized readings can help doctors who are on the front line of care of patients with COVID-19.

The presence of technically trained and specialized staff plus additional equipment is required to obtain an electrocardiographic recording to measure the QT interval, and the intervention demands time to obtain the recording and disinfect the equipment. The KM device is very easy to disinfect due to its small size and lack of leads. We are also aware of the recommendations for measuring the QT interval and that some authors believe that the use of a single ECG lead may underestimate the value of the QT interval. (7) Other

publications have mentioned the use of novel technologies for measuring the QT interval in pediatric and adult populations with single-lead ECG devices, with reliable and robust results in terms of usefulness. (8, 9) Nevertheless, we obtained a very good correlation between the QTc measured with the KM device and with standard ECG in our control group.

Some recordings required an additional lead to confirm the measurements obtained in a standard way, and we chose a precordial bipolar recording at the V1-V2 lead level. This modality has been described as an alternative recording for special situations. (10)

Noisy recordings have been reported with the use of the KM device. (11) This was one of the limitations in our study. The percentage of noisy recordings was 21% (n = 7), but only in 6% (n = 2) of the recordings obtained with the KM device it was an obstacle for the team of specialists to measure the QT interval, and a new recording was required. This difficulty can be solved by repeating the recording or using the precordial lead to obtain clear recordings to properly measure the QTc interval. In a recent communication, the American College of Cardiology recommended that to minimize exposure to COVID-19 and avoid shortage of personal protective equipment (PPE), QTc monitoring may be performed using surrogates for 12-lead ECG assessment, as the KM device. (12)

Limitations

We reported the initial experience of a referral university public hospital, so these results may not be extrapolated to peripheral centers.

The KM device used recorded only single-lead ECG tracings. Although the reliability of this device for measuring the QT interval has been reported, we cannot ignore that 6 or 12-lead ECG recordings provide more complete information on ventricular repolarization time, especially if precordial leads are included.

In our experience, the percentage of noisy recordings was 21%, but only two patients (6%) required an additional recording; thus, the QT interval could be measured in all the patients.

CONCLUSIONS

The use of a KM device to obtain a single-lead ECG recording with digital QTc interval assessment is feasible during the pandemic. Noisy recordings can be solved with an additional recording or by using an alternative precordial bipolar lead.

Conflicts of interest

None declared.

(See authors' conflicts of interest forms on the website/ Supplementary material)

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