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Evaluation of an Electrocardiogram on QR code

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Abstract and Objective

An electrocardiogram (ECG) is an indispensable tool to diagnose cardiac diseases, such as ischemic heart disease, myocarditis, arrhythmia, and cardiomyopathy. Since ECG patterns vary depend on patient status, it is also used to monitor patients during treatment and comparison with ECGs with previous results is important for accurate diagnosis. However, the comparison requires connection to ECG data server in a hospital and the availability of data connection among hospitals is limited. To improve the portability and availability of ECG data regardless of server connection, we here introduce conversion of ECG data into 2D barcodes as text data and decode of the QR code for drawing ECG with Google Chart API. Fourteen cardiologists and six general physicians evaluated the system using iPhone and iPad. Overall, they were satisfied with the system in usability and accuracy of decoded ECG compared to the original ECG. This new coding system may be useful in utilizing ECG data irrespective of server connections.

Keywords:

Electrocardiography, Bar code

Methods

Conversion of ECG to QR code

ECG data in Tohoku University Hospital were retrieved as jpeg format. Image data were converted to text data using programs written in R software (2.14.0), including RImageBook (http://code.google.com/p/rimagebook/) and RImage (http://cran.r-project.org/src/contrib/Archive/rimage/) libraries. First, the original ECG image was converted to a grayscale image with the "imgRGB2Grey" function in the RImageBook library. Second, image data were digitized with "thresholding" function in RImage. Third, data for white pixels were deleted to minimize the volume of data. Fourth, line smoothing was carefully performed to ensure no loss of important information of P, Q, R, and T waves and ST slope. Finally, conversion of the text data into a 2D "quick response" code (QR code) was performed using Google Chart API (https://developers.google.com/chart/?hl=ja). Decode of the QR code were performed using freely available iPhone or iPad Apps, such as QR reader for iPhone/iPad, Qrafer, and i-nigma.

Evaluation of quality and usability

Fourteen cardiologists and six non-cardiologist in Tohoku University Hospital participated in this evaluation study. Items of evaluation were as follows: 1) size of the QR code, 2) usability of decoding with iPhone and iPad, 3) response of the decode, 4) size of decoded ECG, 5) presentation of the style of ECG, 6) accuracy in ECG compared to original ECG data, and 7) total satisfaction. Participants marked score from 0 to 5. Data are shown as the average ± standard deviation of means.

Results

Size of ECG data to QR code

Amount of information a QR code can hold is limited. Although a standard resting ECG contains 5 seconds data including about 4 to 8 beats at 12 leads, two beats or less at six leads or four beats or less at three beats were available in two centimeter square QR code. Within this amount of the ECG data, the QR code is easily recognized by all QR code reader Apps using iPhone or iPad. More ECG data can be converted to QR code but the QR code failed to be recognized in a few seconds. In addition, Google Chart API with simple encoding was used to decrease data size for drawing ECG.

Evaluation of the decoding QR code and decoded ECG

The average age of twenty participated doctors were 36.9 ± 7.9. The years of the carrier in fourteen cardiologists were 11.6 ± 5.2. Eighty-five percent of participants were male.

The average score of the each item was shown as follows: 1) 4.5 ± 0.5 (size of QR code), 2) 4.7 ± 0.4 (usability), 3) 4.8 ± 0.4 (response), 4) 4.4 ± 0.5 (size of decoded ECG), 5) 3.6 ± 0.6 (presentation), 6) 4.8 ± 0.3 (accuracy), and 7) 4.8 ± 0.4 (total satisfaction). Generally, the system was satisfied by participants irrespective of specialty. The score of presentation style was relatively lower than any other items. Although each lead of standard resting ECG is drawn line by line, this system shows six leads were presented in a raw with spaces. Complaint about presentation was only a feeling of strangeness about this appearance.

Conclusion

This study introduced encrypted ECG data into a QR code as text data and decoded by mobile application. The system was evaluated twenty doctors including cardiologists. Overall high satisfaction scores were obtained. Appearance of decoded ECG data shown in a raw was only point which did not satisfied participants. Capacity enlargement of QR codes may improve this demerit. In conclusion, the simple code can be a novel beneficial tool for utilizing ECG data irrespective of the Hospital Information System or Picture Archiving and Communication Systems under special situations, such as natural disasters.