Original Article

Value of Automated ECG Interpretation in Diagnosis of Cardiac Disorders

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Abstract

Background: *Electrocardiography (ECG) is a valuable device in the assessment of cardiovascular diseases. Recent medical software developments such as the invention of modern automated ECG interpreters have greatly facilitated the work of electrocardiographers and cardiologists. We present our experience in the use of one such device in the routine reporting of 200 successive ECGs recorded in our Cardiac Care Unit and Cardiac Emergency Ward.*

Methods: *The interpretations of 200 ECGs provided by the GE-digital ECG device were chosen and compared with those supplied by four cardiologists in a single blind manner. All statistical analyses were performed by using SPSS version 11.5 for windows. A p value of less than 0.05 was considered statistically significant.*

Results: *There was a diagnostic match between the interpretations by the device and those by the cardiologists in 107 (53.5%) cases as opposed to a diagnostic mismatch in 93 cases (46.5%). The matching rate in the interpretations of myocardial ischemic disorders was high, which means practically all the ischemic cases diagnosed by the device were confirmed by the cardiologists. Only in 12 cases myocardial infarction or ischemic changes were reported by the cardiologists, while they were missed by the device. As regards rhythm disorders, the sensitivity and specificity of the device were 67.7% and 75.7%, respectively. With respect to conductive disorders, the respective sensitivity and specificity of the device were 70% and 96.6%, respectively. Finally, in the case of structural disorders, the interpretations of the device were 92.8% sensitive and 83.3% specific.*

Conclusion: *According to the results of our study and similar researches, it seems that the interpretations of an automated ECG device in diagnosing the ischemic and structural disorders of the heart are reliable. The device, however, should not be relied upon when assessing conduction disorders and dysrhythmias. We, therefore, recommend that the users of digital ECG devices recheck the digital interpretations in those cases.*

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Introduction

The past decade has ushered in many technical developments in the routine use of electrocardiography (ECG) in cardiovascular clinics.

March and et al. described the electrophysiology of the heart in the 19th century. Waller recorded the electrical potential of the heart in 1887, and finally the invention of the

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galvanometer by Willem Enith Oven in 1901 paved the way for accurate monitoring of the electrical activity of heart. [1]

Now, the electrocardiogram is a valuable clinical device to evaluate cardiac function and also to diagnose different cardiac diseases. ECG is also useful to assess metabolic disorders such as hypercalcemia and other electrolyte imbalances and to evaluate the cardiac toxicity of special medications.[2,3]

Modern digital electrocardiograms are able to interpret and classify ECGs.[1] It should be noted that although automated ECG interpretation is fast and time-saving, misdiagnosis is probable.[4-6] Indeed, automated ECG interpretation is believed to be unreliable in arrhythmia cases in that it is unable to diagnose P wave.

In addition, automated ECG interpretation is not capable of diagnosing artifacts or subtle changes in ECG waves.[7,8] Digital ECG may have been improved significantly in recent years, with modern computerized devices now being able to interpret ECG almost as accurately as manual interpretation by expert specialists; but the physician should be alert to false positive and negative results.[9-10]

Given the widespread use of a great variety of software across the globe, it is essential that the advantages and disadvantages of each kind of software be meticulously studied.[11]

Methods

This is a prospective analytical study to evaluate the accuracy of the digital electrocardiogram in the interpretation of ECG.

Digital ECG was performed for 200 patients admitted to the CCU and Cardiac Emergency Ward of Ghaem Hospital, using a 3-channel digital ECG device (GE industry of Germany).

All the ECGs were interpreted by four cardiologists, and subsequently the digital and manual interpretations were compared. The results were analyzed in 3 groups of ischemic disorders, rhythm disorders, and structural disorders. Device validity (sensitivity and specificity) in diagnosing cardiovascular disorders was studied.

The averages of parametric values are reported as mean values±SD. The relationship between parametric values was calculated by both paired sample and independent sample t Test. Linear relationships between variable parameters were tested by correlation analysis and stepwise regression. Data were analyzed using SPSS, Version 11.5 statistics software program. Statistically significant differences were accepted at a p value less than 0.05 ($p<0.05$).

Results

ECG abnormalities were divided into 3 groups of ischemic disorders, rhythm disorders, and structural disorders. From a total of 200 cases, myocardial infarction (MI) and ischemic disorders were seen in 107 cases (53.5%), arrhythmia in 47 cases (23.5%), and structural disorders in 31 cases (15.5%).

The results of the digital ECG were similar to our cardiologists' interpretations in 107 cases (53.5%) and were different in 93 cases (46.5%). Technical error (artifact) was seen in 5 cases (2.5%).

The digital ECG device correctly diagnosed 106 cases of MI (acute MI) and ischemic heart disease (IHD). The device missed IHD in 12 cases. In these cases, ST segment changes were missed in 3 (25%), posterior MI was missed in 1 (8.5%), anteroseptal MI was missed in 1 (8.5%), and inferior MI was missed in 7 (58%) persons. The device reported 1 case of MI, but the MI pattern was not detected by the cardiologists. With respect to IHD, the interpretations of the digital ECG device had a sensitivity of 89.8%, specificity of 98.7%, positive predictive value of 99%, and negative predictive value of 87%. (Table 1)

Table 1. Validity test for ischemic heart disorders

Total Cases	physician		Device
	Non-diagnosis	Diagnosis	
107	1	106	Diagnosis
93	81	12	Non-diagnosis
200	82	118	Total Cases

Structural disorders were reported in 44 cases including 4 cases of mismatch diagnosis with low voltage ECG, 15 cases of mismatch diagnosis with enlarged atrium, 1 case of right ventricular hypertrophy (RVH), and 4 cases of left ventricular hypertrophy (LVH). The device also reported 2 cases of right axis deviation and 5 cases of left axis deviation, which did not chime in with the cardiologists' interpretations. The device correctly diagnosed 13 cases of structural disorders. A case of right atrium enlargement was missed by the device.

With regard to structural disorders, the interpretations of the digital ECG device had a sensitivity of 92.8%, specificity of 83.3%, positive predictive value of 92.8%, and negative predictive value of 99.3%. (Table 2)

Table 2. Validity test for structural disorders

Total Cases	physician		Device
	Non-diagnosis	Diagnosis	
44	31	13	Diagnosis
156	155	1	Non-diagnosis
200	186	14	Total Cases

Conductive disorders were divided in two groups: atrioventricular node conductive disorders (75%) and fascicular conductive disorders (25%). The mismatch rate between the interpretations by the device and those by the cardiologists was the same in these two groups.

The ECG device correctly diagnosed conductive disorders in 20 cases but misdiagnosed 2 cases of atrioventricular block (AVB), 2 cases of right bundle branch block (RBBB), 1 case of left bundle branch block (LBBB), and 1 case of sino-atrial (SA) block. The cardiologists confirmed 14 cases of conductive disorders. The device also missed 2 cases of complete AVB, 2 cases of RBBB, 1 case of LBBB, and 1 case of interventricular conduction delay.

With respect to conductive disorders, the interpretations of the digital ECG device had a sensitivity of 70%, specificity of 96.6%, positive predictive value of 70%, and negative predictive value of 96.6%. (Table 3)

Table 3. Validity test for conductive disorders

Total Cases	physician		Device
	Non-diagnosis	Diagnosis	
20	6	14	Diagnosis
180	174	6	Non-diagnosis
200	180	20	Total Cases

The digital ECG device correctly diagnosed arrhythmia in 62 cases. There were 34 reported cases of premature ventricular contractions (PVC), 4 of which had artifact. The device reported 3 cases of premature atrial contractions (PAC) and 4 cases of atrial fibrillation (AF), which did not tally with the cardiologists' interpretations. The device missed 1 case of PVC, 1 case of PAC, 7 cases of AF, and 1 case of paroxysmal supraventricular tachycardia (PSVT). The device accurately diagnosed 41 cases with arrhythmia.

As regards arrhythmia, the interpretations of the digital ECG device had a sensitivity of 67.7%, specificity of 75.7%, positive predictive value of 33.8%, and negative predictive value of 92.7%. (Table 4)

Table 4. Validity test for arrhythmia

Total Cases	physician		Device
	Non-diagnosis	Diagnosis	
62	41	21	Diagnosis
138	128	10	Non-diagnosis
200	169	31	Total Cases

The digital ECG device reported pacemakers in 15 cases. Among them, a correct diagnosis was seen only in 8 patients with a unipolar lead. Mismatch diagnosis was observed in 2 unipolar and 5 bipolar leads. With respect to the diagnosis of pacemakers, the interpretations of the digital ECG device had a sensitivity of 53%, specificity of 100%, positive predictive value of 100%, and negative predictive value of 96%. (Table 5)

Table 5. Validity test for pacemaker

Total Cases	physician		Device
	Non-diagnosis	Diagnosis	
8	0	8	Diagnosis
192	185	7	Non-diagnosis
200	185	15	Total Cases

Discussion

Modern automated ECG interpreters were invented during the last decade and since then they have become almost ubiquitous in emergency wards, outpatient clinics, and primary care units the world over. Be that as it may, a definite answer has yet to emerge as to whether or not manual interpretation could be entirely replaced by digital devices.[12-17]

Recent improvements in diagnostic software have enhanced the reliability of such devices, but blind acceptation of them may lead to misdiagnosis.[11,18] Indeed, the diagnostic errors of digital ECG interpreters can detract from their positive aspects, i.e. speed and cost-effectiveness.[19,20] Our findings showed that IHD and MI constituted the bulk of heart diseases in emergencies and that automated ECG interpreters demonstrated a good validity in both cases (P=0.001). Our results also demonstrated that while computerized ECG interpretation was acceptable in structural disorders, it was not reliable in arrhythmia, conductive disorders, and pacemaker diagnosis (P=0.881, P=0.322 and P=0.341 respectively).

We suggest that the automated ECG interpretation of conductive disorders and arrhythmias be rechecked by cardiologists. The validity of computerized ECG interpretation should be enhanced through the upgrading of the applied software.

Conclusion

According to the results of our study and similar research, it seems that the interpretations of an automated ECG device in diagnosing the ischemic and structural disorders of the heart are reliable. The device, however, should not be relied upon when assessing conduction disorders and dysrhythmias. We, therefore, recommend that the users of digital ECG devices recheck the digital interpretations in those cases.

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