

Research Letter

Accuracy of machine electrocardiogram interpretation and implementation of a de-prioritization protocol in the emergency department

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Computer analysis of electrocardiograms (ECGs) was introduced more than 50 years ago, with the aim to improve efficiency and clinical workflow.^[1,2] However, inaccuracies have been documented in the literature.^[3,4] Research indicates that emergency department (ED) clinician interruptions occur every 4–10 min, which is significantly more common than in other specialties.^[5] This increases the cognitive load and error rates and impacts patient care and clinical efficiency.^[1,2,5] De-prioritization protocols have been introduced in certain centers in the United Kingdom (UK), removing the need for clinician ECG interpretation where ECGs have been interpreted as normal by the machine.

Our primary aim was to evaluate the accuracy of machine ECG interpretation in the ED. Our secondary aim was to evaluate the effect of a pre-prioritization protocol on patient flow within the ED, thus reducing ED clinician interruptions and improving the clinical workflow and productivity.

We collected data from 302 consecutive 12-lead ECGs within a large single-center ED in northwestern England. Consecutive ECGs, containing a machine interpretation, were collected within the triage bay of the ED. Mindray R12 was the model of the ECG machine used throughout. ECGs were then reviewed independently by two different cardiologists, who were blinded to the machine interpretation.

A de-prioritization protocol was implemented as outlined in supplementary Table 1. This protocol removed the need for ECGs to be reviewed by clinicians if the machine interpretation was normal. Data were collected

on consecutive ECGs taken in the ED triage bay for a rolling 5-day period before implementation and after implementation of the protocol. We recorded the time of ECG recording and the time of ambulatory emergency care unit (AECU) arrival for those patients who were transferred. The AECU accepts patients who do not need hospital admission to provide same-day emergency care before discharge. Streamlining patients to the AECU reduces the burden on ED capacity and waiting time, which are driven primarily by delays in hospital admission and bed availability. Therefore, reducing the duration to the AECU arrival time improves the clinical flow and reduces the burden on the ED.

The negative predictive value (NPV) was calculated to determine the predictive value of “normal” machine ECG interpretation. The positive predictive value (PPV) was calculated to determine the predictive value of an “abnormal” machine ECG interpretation compared to the cardiologist interpretation, which determined the presence of an abnormality. Independent samples *t*-tests were used to test the null hypothesis that there was no difference in the mean time duration between ECG recording and AECU arrival across the sample before versus after implementation of the de-prioritization protocol. All data analysis was conducted via IBM SPSS® Statistics version 29.0.2.0 and Microsoft Excel®.

Among the 302 ECGs collected, 50.7% (*n*=153) were marked as “normal” by machine interpretation (Table 1). Among those ECGs marked “normal” by machine interpretation, 94.1%

Table 1. Machine interpretation and cardiologist interpretation of electrocardiograms

Machine interpretation	Cardiologist concurrence with machine interpretation, <i>n</i> (%)		
	0	1	2
Normal (<i>n</i> =153)	9 (5.9)	38 (24.8)	106 (69.3)
Abnormal (<i>n</i> =149)	18 (12.1)	44 (29.5)	87 (58.4)

0: no cardiologist concurrence; 1: one of two cardiologists in agreement with machine interpretation; 2: both cardiologists in agreement with machine interpretation.

($n=144$) demonstrated concurrence with at least one cardiologist reviewers. The interpretation of the ECGs where there was non-concordance between cardiologists would not have required immediate review based on interpretation and would not have changed the management plan or delayed AECU transfer. Therefore, the NPV of “normal” machine ECG interpretation was 94.1%, and the PPV of “abnormal” machine ECG interpretation was 87.9%.

The mean duration to AECU arrival before and after implementation was 9.88 ± 5.27 h and 3.42 ± 4.15 h, respectively. This demonstrated a significant decrease in the time taken between ECG recording and AECU arrival following implementation of the protocol ($P < 0.0001$).

Figure 1 contains a boxplot, illustrating the time duration between ECG recording and AECU arrival across all patients receiving an ECG during the sample collection, stratified by those ECGs collected before protocol implementation versus after implementation.

Our results demonstrated a good NPV of 94.1% about “normal” machine ECG interpretation. Following implementation of a de-prioritization protocol, the duration between ECG recording and AECU arrival was significantly reduced ($P < 0.0001$). This may demonstrate an improvement in patient flow through the ED, reduced clinician interruption and improved clinical efficiency.

There are various strengths associated with our study design. We collected data on consecutive ECGs, minimizing the selection bias associated with convenience sampling. This was a single-center project, and as such, clinical and institutional practices remained largely consistent across all patients. The blinding of cardiologists to machine ECG

interpretation and each other’s interpretation minimized biases associated with prior knowledge of machine or colleague ECG interpretation. The use of the same two cardiologists for all the ECGs in the sample ensured the consistency of the ECG analysis approach.

There are several limitations associated with this study protocol. The single-center nature of this – while promoting practice consistency – limits the generalizability of our results to the general population and other healthcare settings. The use of one ECG machine model also limits the generalizability to other centers, which may use a variety of different machine models. The use of a relatively new computer patient record system has made the recording of time admitted to different departments less reliable, as clinicians and bed managers adapt to the new system. This may have caused inaccuracies in the time documentation of patient transfer and arrival durations. We also did not assess user satisfaction in relation to the ECG protocol, which may have added further value to our work.

In conclusion, our data suggest that implementation of ECG de-prioritization protocols relying on machine ECG interpretation may improve patient flow in the ED. However, further research is required to assess the effect on clinician interruptions and efficiency in order to promote widespread adoption of this protocol.

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Ethical approval: This project was reviewed by the East Lancashire Hospitals NHS Trust Research & Development Team. All data were anonymized prior to analysis. As it takes the form of a healthcare survey, no ethical approval was required.

Conflicts of interest: There are no conflicts of interest.

Contributors: All authors contributed to the design and interpretation of the study.

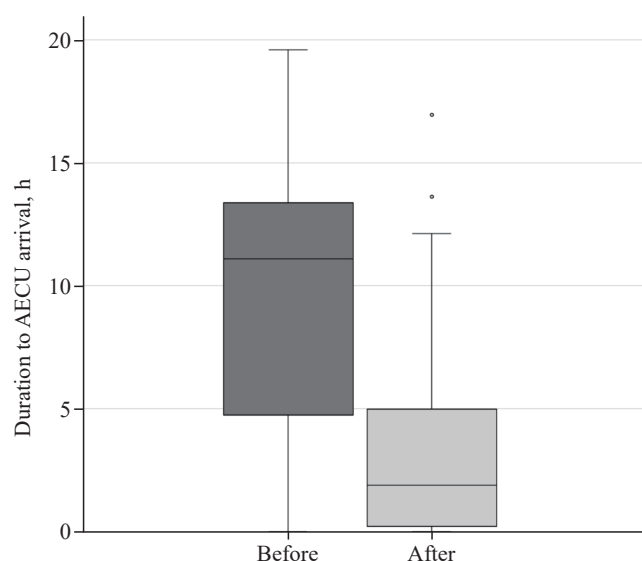


Figure 1. Boxplot showing the distribution of durations between ECG recording and AECU arrival before and after implementation of the de-prioritization protocol. ECG: electrocardiogram; AECU: ambulatory emergency care unit.

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