



# Getting to the heart of the issue: senior emergency resident electrocardiogram interpretation and its impact on quality assurance events

Leslie A Bilello<sup>1</sup>, Céline Pascheles<sup>1</sup>, Kiersten Gurley<sup>1</sup>, Douglas Rappaport<sup>2</sup>, David T Chiu<sup>1</sup>, Shamai A Grossman<sup>1\*</sup>, Carlo L Rosen<sup>1\*</sup>

<sup>1</sup>Department of Emergency Medicine, Beth Israel Deaconess Medical Center, Boston, MA, USA

<sup>2</sup>Department of Emergency Medicine, Mayo Clinic Hospital, Phoenix, AZ, USA

**Objective** Electrocardiogram (ECG) interpretation skills are of critical importance for diagnostic accuracy and patient safety. In our emergency department (ED), senior third-year emergency medicine residents (EM3s) are the initial interpreters of all ED ECGs. While this is an integral part of emergency medicine education, the accuracy of ECG interpretation is unknown. We aimed to review the adverse quality assurance (QA) events associated with ECG interpretation by EM3s.

**Methods** We conducted a retrospective study of all ED ECGs performed between October 2015 and October 2018, which were read primarily by EM3s, at an urban tertiary care medical center treating 56,000 patients per year. All cases referred to the ED QA committee during this time were reviewed. Cases involving a perceived error were referred to a 20-member committee of ED leadership staff, attendings, residents, and nurses for further consensus review. Ninety-five percent confidence intervals (CIs) were calculated.

**Results** EM3s read 92,928 ECGs during the study period. Of the 3,983 total ED QA cases reviewed, errors were identified in 268 (6.7%; 95% CI, 6.0%–7.6%). Four of the 268 errors involved ECG misinterpretation or failure to act on an ECG abnormality by a resident (1.5%; 95% CI, 0.0%–2.9%).

**Conclusion** A small percentage of the cases referred to the QA committee were a result of EM3 misinterpretation of ECGs. The majority of emergency medicine residencies do not include the senior resident as a primary interpreter of ECGs. These findings support the use of EM3s as initial ED ECG interpreters to increase their clinical exposure.

**Keywords** Electrocardiography; Quality assurance, health care; Emergency medicine; Education, medical, graduate

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Correspondence to: Leslie A Bilello  
Department of Emergency Medicine,  
Beth Israel Deaconess Medical Center,  
1 Deaconess Road, 2nd Floor, Boston,  
MA 02215, USA

E-mail: [lbilello@bidmc.harvard.edu](mailto:lbilello@bidmc.harvard.edu)

ORCID

<http://orcid.org/0000-0002-4702-729X>

\*Co-authors for senior authorship



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## Capsule Summary

### What is already known

*Previous educational research has suggested that only a small minority of emergency medicine programs allows senior residents the opportunity to perform primary electrocardiogram (ECG) interpretation in the clinical setting. Our residency program is part of the minority that allows senior emergency medicine residents to act as primary interpreters of ECGs.*

### What is new in the current study

*We performed a study investigating ECG misinterpretation and error rates within our academic institution. We found a low error rate associated with this ECG interpretation model. We feel this deliberate practice model represents a novel approach to ECG interpretation curriculum.*

## INTRODUCTION

Electrocardiogram (ECG) interpretation is an essential skill for emergency medicine (EM) physicians. Diagnostic accuracy is imperative for patient safety, national quality assurance (QA) metrics, and communication with other providers.<sup>1,2</sup> While this is of critical importance, there is a lack of consensus regarding ECG curricula and interpretation methods across EM residencies in the United States.<sup>3-5</sup>

There are a myriad of approaches to ECG interpretation curricula both as required training and elective learning experiences. There are also significant differences in clinical ECG interpretation experiences among EM residency programs in the United States. According to a recent study only a small minority of programs (13%) provide senior EM residents (EM3s) the opportunity to perform primary ECG interpretation in a clinical setting.<sup>6</sup> The majority (87%) have an attending perform initial ECG interpretation. The American College of Cardiology and the American Heart Association mandate that ECGs be performed and read within 10 minutes in all cases of ED patients who present with symptoms that are suggestive of acute myocardial infarction, but these guidelines do not specify who must read these ECGs.<sup>7</sup>

Our institution incorporates EM3s as the primary interpreters of all ED ECGs, whether they are performed rapidly within the first 10 minutes of presentation or anytime during the patient's care. ECGs are brought directly from the bedside to the EM3 by an ED technician for real-time interpretation. Each EM3 writes their ECG interpretation on the ECG paper as confirmation of their primary interpretation. An EM3 will bring the ECG to the immediate attention of their attending physician if they identify a concerning abnormality, otherwise the attending physician reviews the ECG later during the clinical shift. Our EM3s' autonomy provides increased exposures, with the aim of mitigating future diagnostic errors and increasing patient safety. The objective of

the current study was to further review this novel senior resident role and investigate associated errors and significant adverse QA events.

## METHODS

We conducted a retrospective study of all ED ECGs performed between October 2015 and October 2018, all of which were primarily interpreted by an EM3. The study took place at an urban, tertiary care, academic medical center that treats 56,000 patients per year. This medical center has a 3-year EM residency with 13 residents per class. The time period utilized in this study involved four different classes of senior residents, constituting a total of 52 EM3s. The EM faculty, residents, nurses, and/or specialty consultants such as cardiologists can refer QA cases via an electronic database. We reviewed all cases referred to the ED QA Committee during the study period. All cases were classified using the following five error categories: not acquiring necessary information; not acting on data that were acquired; knowledge gaps by clinicians; communication gaps; and systems issues/resource utilization error.

Cases within each category were evaluated via an 8-point Likert scale to assess error, preventable adverse events, and non-preventable adverse events (Tables 1, 2). Each case perceived as involving an error or the potential for patient harm was referred to a 20-member committee of ED leadership staff, attendings, residents, and nurses for further review. Committee members were blinded, and inter-rater reliability was assessed to investigate the extent to which all members agreed on outcomes. In cases where consensus could not be achieved, the director and vice director of the committee reviewed the case independently of the committee. Ninety-five percent confidence intervals (CIs) were calculated. The study was reviewed by the relevant institutional review board at Beth Israel Deaconess Medical Center (2018D000755) and met exemption criteria.

Table 1. QA committee error criteria

Score	Description	Performance level	QA response
1	No error	Perfect	No reviewer feedback to team necessary, no QA committee review necessary
2	Judgement calls that the reviewer may not have made but can accept; with no apparent consequences	Minor flaws	No reviewer feedback to team necessary, no QA committee review necessary
3	Possible errors in care of little consequence that did not compromise care in any appreciable way	Minor flaws	Reviewer gives feedback to team, but no QA committee review necessary
4	Moderate errors with resulting consequences that had the potential to compromise care, but which did not appear to compromise care	Moderate flaws	Discussion in QA committee with appropriate feedback and +/- remediation
5	Moderate errors with resulting consequences that may have compromised care	Moderate flaws	Discussion in QA committee with appropriate feedback and +/- remediation
6	Major errors with consequences that compromised care but where the overall care was within the standard of care	Major flaws	Discussion in QA committee with appropriate feedback and +/- remediation
7	Major errors that resulted in compromised care and which violated the standard of care	Major flaws	Discussion in QA committee with appropriate feedback and +/- remediation
8	Major errors that grossly violated the standard of care	Egregious	Discussion in QA committee with appropriate feedback and +/- remediation

QA, quality assurance.

Table 2. QA committee adverse error criteria

Score	Description	Performance level	QA response
1	No adverse event occurred	No error/no harm	No reviewer feedback to team necessary, no QA committee review necessary
2	An event may have occurred that had the capacity to cause injury, but did not reach patient	Near miss	No reviewer feedback to team necessary, no QA committee review necessary
3	An event occurred that may have reached the patient, but did not cause harm	Near miss	Reviewer gives feedback to team, but no QA committee review necessary
4	Circumstances or events required additional monitoring or screening tests (e.g., telemetry, serial physical examinations or lab test) but did not require additional treatment	Monitoring only	Discussion in QA committee with appropriate feedback and +/- remediation
5	An event occurred that resulted in the need for treatment or intervention, and caused temporary patient harm/injury/need for additional treatment	Minor	Discussion in QA committee with appropriate feedback and +/- remediation
6	An event occurred that resulted in initial (if outpatient) or prolonged hospitalization and caused temporary patient harm/injury/disease progression	Moderate	Discussion in QA committee with appropriate feedback and +/- remediation
7	An event occurred that resulted in permanent patient harm/injury/disease progression	Major	Discussion in QA committee with appropriate feedback and +/- remediation
8	An event directly contributed to death of patient (n.b., do not check if patient death was unrelated to event)	Death	Discussion in QA committee with appropriate feedback and +/- remediation

QA, quality assurance.

## RESULTS

A total of 92,928 ED ECGs were performed between October 2015 and October 2018, all of which were primarily interpreted by EM3s. Of these, 3,983 ED QA cases were referred for quality of care review during the study period. QA referrals stemmed from 72-hour returns to the ED with subsequent admission, hospital ward admissions requiring transition to the intensive care unit within 24 hours, death within 24 hours of ED arrival, and patient or physician complaints. An error was identified in 268 QA cases (6.7%;

95% CI, 6.0%–7.6%). Four of the 268 errors involved a resident ECG misinterpretation or failure to act on an ECG abnormality (1.5%; 95% CI, 0.0%–2.9%). All four cases were categorized as belonging to the error category "not acting on data that were acquired."

Of the four QA cases identified in the current study, one involved an EM3 who did not recognize evolving ECG changes during an ED visit, and another error resulted when an EM3 did not request immediate evaluation of a patient in triage with an ECG that demonstrated sinus tachycardia at 140 beats per minute.

There are clear guidelines at the study institution that mandate immediate evaluation of a patient with such significant tachycardia (> 130 beats per minute), therefore the EM3 in the aforementioned case did not follow appropriate protocol. A third case involved a patient with a dual chamber pacemaker presenting with chest pain. The patient's ECG demonstrated inappropriate ventricular pacing that was acutely new compared to a previous ECG. While there was no adverse event, an error was attributed to the EM3 because they failed to identify this change. These three instances were categorized as "moderate errors with resulting consequences that had the potential to compromise care, but which did not appear to compromise care" (Table 1).

The only case in which there was an adverse outcome involved a missed posterior ST-segment elevation myocardial infarction (STEMI). Although the misinterpreted posterior STEMI ECG was identified shortly thereafter by the attending physician, this delay in activation of the catheterization lab was considered an adverse outcome. This case was categorized as a "near-miss" because "an event occurred that may have reached the patient, but did not cause harm" (Table 2).

## DISCUSSION

The EM literature provides little guidance with regard to the optimization of ECG interpretation curricula.<sup>9-11</sup> In our training program residents are exposed to ECG interpretation teaching via didactic lectures, asynchronous learning modules, one-on-one dedicated training, and textbook review. Trainees also take the annual American Board of Emergency Medicine In-Training Examination, which includes ECG interpretation and questions related to cardiac emergencies. The culmination of this curriculum is a unique role as a primary ECG interpreter during their senior year.

Our program employs the deliberate practice (DP) model, which creates a learning environment in which EM3s perform primary ECG interpretation via a purposeful approach, with subsequent attending physician assessment. Specifically, the attending physician independently interprets the ECG during the same clinical shift and provides direct feedback to the EM3. This method incorporates repetitive skill utilization with the aim of improving diagnostic and clinical skills.<sup>12-14</sup>

Most EM training programs do not incorporate this unique role in which residents perform primary ECG interpretation.<sup>6</sup> At our institution we feel this responsibility and practice is an integral part of EM3s' education prior to becoming independent attending physicians. While we cannot define the ideal ECG interpretation practice, this DP method represents a potential innovation compared to ECG curricula at other EM residencies.

A low percentage of the cases referred to the QA committee were a result of EM3 misinterpretation of ECGs, but there is no known national ECG interpretation error rate for United States-trained residents or attending physicians available for comparison. Data comparing EM malpractice cases involving residents with cases in which only the attending physicians were named have been reported.<sup>15</sup> In that study, in the resident cases there was a statistically significantly higher percentage of cardiac-related cases than there was in the attending physician-only cases. While that investigation was not specifically focused on ECG misinterpretation or the unique EM3 role described herein, those findings emphasize the importance of honing ECG interpretation skills during residency to improve clinical skills, mitigate errors, and improve patient safety.

The present study was limited in that it was performed at a single institution and there is no known national ECG interpretation error rate for United States-trained residents available for comparison. While there is a robust QA reporting system at the study institution, there is an inevitable possibility that some missed cases or errors were not brought to the attention of the QA committee.

The current study was designed to investigate the role of EM3s as initial interpreters of ECGs in a clinical ED setting. The use of the DP model in the context of EM3 ECG interpretation in our ED is associated with a low percentage of errors and adverse QA events. Further studies are needed to investigate and compare specific error or miss rates attributed to resident and attending physician ECG interpretation at other institutions in order to determine whether this DP model is a reliable method that can be broadly implemented across EM residencies.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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