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Emergency physicians should interpret every triage ECG, including those with a computer interpretation of "normal"

Occlusion myocardial infarction (OMI) is a common, time sensitive, life threatening diagnosis, and 30–50% of OMI do not meet STEMI criteria [STEMI(-) OMI]. In OMI, a short door-to-ECG interpretation time is critical for rapid reperfusion of ischemic myocardium before irreversible infarction. Therefore, all patients with symptoms that could be attributable to OMI undergo a rapid screening ECG, even though only 1–3% of such ED patients have STEMI(-) OMI [1]. Unsurprisingly, these screening ECGs infrequently yield actionable findings. Given that emergency physicians (EPs) would like to find ways to reduce cognitive load, it is tempting to believe that the computer interpretation of "normal ECG" is sufficient to preclude physician review of these ECGs, and there are publications which claim to support this idea [2-5].

Recently, Winters et al. published an article in which 989 ECGs interpreted as "normal" by the computer were then overread by a cardiologist [6]. By those methods, it is not surprising that no immediately actionable electrocardiographic findings were missed by a "normal" computerized interpretation. The authors conclude that a computerized interpretation of "normal" may reassure us that there is no immediately actionable underlying pathology which an EP overread would change. While this conclusion is tempting, it is false.

Utilizing cardiology as the reference standard is flawed. Hillinger et al. demonstrated that computerized interpretation for OMI by STEMI criteria has a sensitivity of 35% for OMI while cardiologists had a sensitivity of 49% [1]. The reference standard for OMI must not be a cardiologist; it must be an after-the-fact determination of the presence or absence of OMI. In our publications, OMI is ruled in by an (emergent or delayed) angiogram with a culprit lesion and A) TIMI 0/1/2 flow or B) culprit with TIMI-3 flow and high troponin. OMI may be ruled out if acute MI is ruled out by serial troponins [7-9]. By this methodology, true experts have 90% sensitivity for OMI, identifying over twice as many as STEMI criteria [7]. Computer algorithms are designed and tested for accuracy for STEMI(+) OMI, but not for subtle OMI with lesser ST Elevation [i.e., STEMI(-) OMI] [7-9]. Although it is likely that the computer will recognize most STEMI(-) OMI as having "Nonspecific ST-T abnormalities," we have collected over 30 cases of OMI in which the computer interpretation was "normal;" in most cases, the physician was able to discern some abnormality which led to early reperfusion [10]. Fig. 1 is one example.

Litell et al. showed that, in their institution, it would take approximately 1000 "normal" ECGs to miss just one STEMI(-) OMI; thus, a study showing that "normal ECG" is sensitive enough would require a population of thousands of "normal" ECGs [11]. In fact, in the Winters study, two patients who underwent cardiac catheterization and had coronary lesions amenable to intervention were not identified by cardiology overread; we are neither told whether they had OMI or Non-Occlusion MI (NOMI) nor do they show us those ECGs. We have shown that using OMI criteria beyond can correctly identify OMI that STE criteria either diagnose with delay or entirely miss [8,9]. Moreover, we have demonstrated that STEMI(+) OMI and STEMI(-) OMI cohorts have similar infarct size [7,8]. Other studies of NSTEMI patients who were randomized to immediate vs. delayed reperfusion found profound benefit for those who had persistent chest pain and underwent angiogram within 2 h of arrival [12]. Thus, those with STEMI(-) OMI benefit from emergent reperfusion therapy similarly to those with STEMI(+)OML

Also, cardiologists are not in the position to diagnose hyperkalemia nearly as often as are EPs; they are unlikely to be better than EPs at this task and are a poor reference standard. In this study, 6 patients were found to have serum potassium concentration > 6.0 mEq/L. One individual had a serum potassium concentration of 6.6 mEq/L and was noted to have "nonspecific ST and T wave abnormalities." Though hyperkalemia may have nonspecific findings, the electrocardiographic manifestations of hyperkalemia are complex and can be specific if the interpreter has been trained to identify them. Though both humans and computers might label as "normal" some ECGs that in reality manifest hyperkalemia, this study does not support that if the computer calls it normal, the EP will also. See Fig. 2.

Although physician burnout is an important problem, there is no evidence that reading ECGs contributes to it. This study does not show that reliance on a computer that is not programmed to recognize STEMI(-) OMI or subtle manifestations of hyperkalemia is safe. Such a study would require large numbers, have real outcomes, and prove that emergency physicians could not be trained to recognize the associated abnormalities. Until then, we strongly advocate for all EPs to continue to interpret all triage ECGs, "normal" or otherwise.

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Fig. 1. ECG of a patient presenting with chest pain. Hyperacute T waves and STE are seen in leads V1–V3 that are diagnostic of LAD Occlusion. Computer interpretation of "normal." There was a delay of care as these ECG findings were not recognized as manifestation of OMI. The patient had a 100% LAD OMI at the time of cardiac catheterization.



Fig. 2. ECG of a patient presenting for failed dialysis catheter. There are peaked T waves and sinus bradycardia present. ECG interpretation is normal. Serum potassium concentration was 6.8 mEq/L. The EP recognized these ECG manifestations of hyperkalemia and the patient was treated without adverse outcome.

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## Author contributions

All authors contributed equally and meaningfully to the conception, writing, and editing of this manuscript.

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**Alexander Bracey:** Conceptualization, Writing – original draft, Writing – review & editing. **H. Pendell Meyers:** Conceptualization, Writing – original draft, Writing – review & editing. **Stephen W. Smith:** Conceptualization, Writing – original draft, Writing – review & editing.

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We have no conflicts of interest to disclose.

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