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Emergency physicians should be shown all triage ECGs, even those with a computer interpretation of "Normal"

Acute coronary occlusion is a time-sensitive emergency. Substantial multidisciplinary resources are devoted to its rapid identification and management. These include protocols that seek to minimize door-to-balloon time, which begin with accurate and timely recognition of patients with electrocardiographic manifestations of occlusion myocardial infarction. Initial recognition often happens in the emergency department (ED) triage area, where ECGs are commonly obtained at the discretion of screening personnel and promptly shown to a physician for confirmation. Computer algorithms flag key patterns, but in most cases a physician is interrupted multiple times per shift to interpret a steady stream of ECGs. An evolving body of literature suggests that these and other interruptions may pose a risk to physicians and patients; perhaps the computerized interpretation of "Normal" is good enough. Based on our experience and data, we disagree.

Although a series of studies [1–3] tout the reliability of computerized ECG interpretation, a closer reading, paired with data from our ED, supports our skepticism. In a recent prospective cohort study examining triage ECGs, Hughes and colleagues [4] contend that a computerized interpretation of "Normal" is reliable enough to forego physician review. They justify their conclusion with the 99% negative predictive value in their single-center study and they bolster their position by a reference to recent literature describing the phenomenon of task overload among emergency physicians. In short, their rationale is that computer algorithms are so unlikely to misread an acute MI as "Normal" that interrupting a physician for confirmation is unnecessary or even detrimental. The implications are tempting. EDs are often fast-paced, decision-dense environments. Reducing unnecessary interruptions by using artificial intelligence to minimize human fallibility has substantial face validity. Unfortunately, their conclusions are drawn from incomplete data that are unlikely to improve with further scrutiny. The study was underpowered. Hughes and colleagues enrolled a prospective cohort of 855 patients from which they identified 255 (25%) with a triage ECG interpreted electronically as "Normal". Thirteen (5%) of these were deemed abnormal by a non-blinded cardiologist reviewer but the ultimate clinical outcome is only reported for a single patient. Using non-blinded expert review rather than outcome as a reference standard precludes any meaningful conclusion about triage ECGs.

Both the computer interpretation and the STEMI criteria themselves are flawed tools. Standard ST segment elevation criteria are significantly limited in their ability to identify acute coronary occlusion MI [5,6]. Commonly employed computer algorithms are about 60% sensitive for STEMI as diagnosed by an expert [7]. It is unknown from studies comparing computer interpretation with expert review how many STEMI were misinterpreted as "Normal" or "Nonspecific ST-T abnormality", etc. [7,8]. Further complicating matters, computer-generated diagnoses are also known to bias subsequent ECG interpretation by both experts and nonexperts [9].

To illustrate the limitations imposed by sample size, recent data from our institution reveal that we identify approximately 225 type I myocardial infarctions (MI) in a typical year. These include about 60 occlusion MI with clear ST segment elevation (none of which would be called "Normal" by the computer) and about 165 NSTEMI. Of the NSTEMI in our cohort, about 25% will actually have acute coronary occlusion. While most of these roughly 40 NSTEMI occlusions would be read by the computer algorithm as abnormal in some way (typically nonspecific ST segment or T wave abnormality), they would not be labelled STEMI. We might conservatively estimate that five of these 40 acute coronary occlusion MIs without ST segment elevation would be erroneously read by the computer as "Normal". That is five acute coronary occlusion MIs *per year* misread by the computer algorithm as normal. In that same year we collect approximately 24,000 ECGs in our ED, of which 20% are called "Normal" by the computer. Taken together, these data suggest that out of 5000 "Normal" ECGs in a given year, about five will actually be acute coronary occlusion MIs that have been misinterpreted by a computer algorithm. A sample size of 855 has no chance of generating a meaningful conclusion about the reliability of computer "Normal". In fairness to Hughes, it is not certain that an average emergency physician will catch these few false normals, but they will absolutely go missed if the physician never sees them. We would prefer to be interrupted.

It is reasonable to challenge the current hypervigilant approach to obtaining triage ECGs. However, given the limitations of available data and the risk associated with missed coronary occlusion, a single false negative example invalidates the conclusion that the computer interpretation of "Normal" is good enough. We have included two examples in this editorial (Figs. 1–2b) as well as a link to several others [10].

Another argument against the liberal use of triage ECGs is that it is expensive. In a retrospective chart review published this year, Noll and colleagues [11] used an even smaller cohort to derive a cost associated with employing relatively loose triage ECG indications to detect myocardial infarction as early as possible. They calculate a billing rate of $125 per ECG. If we apply that to our institution's ECG data described above, this means that we spent just over $13,000 on ECGs to identify one coronary occlusion MI. This is less than one fourth of what Noll and colleagues report spending at their institution. It is still a large sum, but relatively modest compared to the medical (and potential legal) costs associated with missed MI. For that matter, hospital charges grossly overestimate the true cost of services. The costs reported by Noll et al are likely inflated. Given the consequences of missing OMI, this metric is not particularly relevant.

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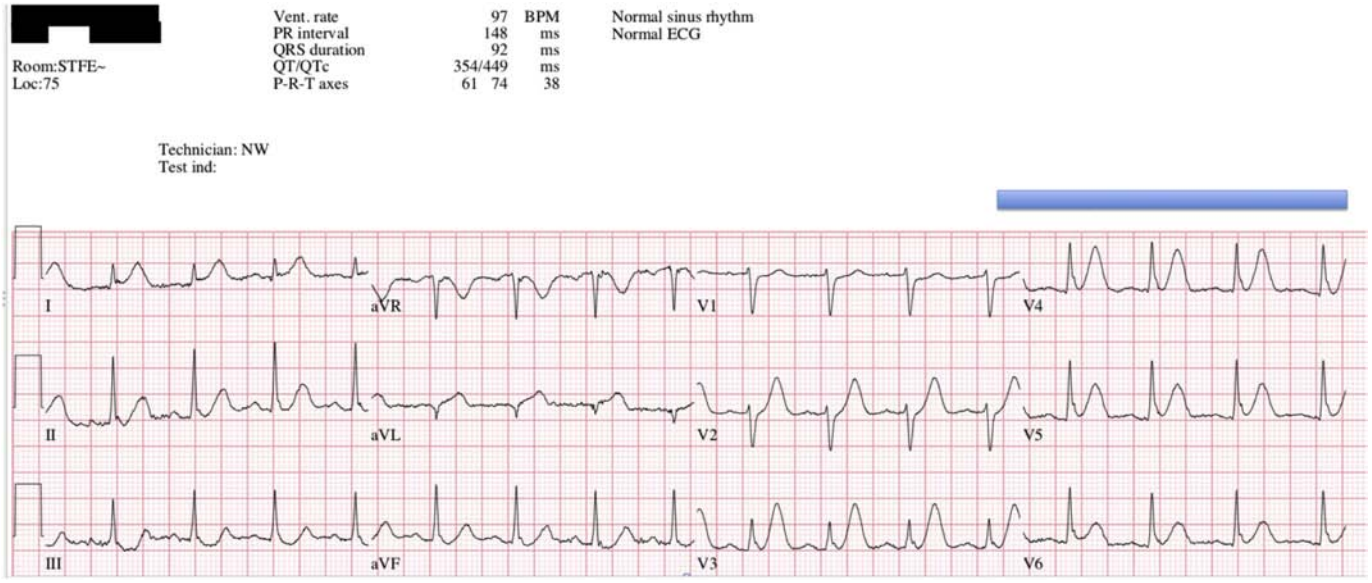

Fig. 1. The perils of a computer interpretation of "Normal" include the grossly abnormal, such as this middle-aged woman who presented with 1 h of chest discomfort. Her "Normal" ECG shows obvious hyperacute T waves. Emergent cardiac catheterization revealed LAD occlusion.

The clinical impact of physician interruption for ECG interpretation is relevant, but the solution is not deference to imperfect algorithms. Skaugset and colleagues' [12] landmark 2016 review of task switching and multitasking among emergency physicians describes the impact of various interruptions and strategies to minimize associated harm. Without a doubt, emergency physicians work in a highly distracting environment. The combination of limited patient information, high acuity, stressful circumstances, open-plan workspaces, unpredictable sensory stimuli, and variable staffing (to name just a few factors) make the ED a challenging place to perform sophisticated cognitive work. Heuristics, team communication strategies, and individual experience all serve to augment the individual clinician's ability to perform at peak capacity, but many challenges remain. Perhaps what emergency physicians need is more effective task management strategies, better use of ancillary staff, scribes, electronic tools, etc. Managing interruptions and maintaining task continuity are trainable skills, but so is rapid, skillful identification of time-sensitive ECG abnormalities.

ED triage is often a chaotic environment with poor correlation between the issues gleaned by triage personnel and the patient's final diagnosis. These areas are not always staffed by personnel with expertise in subtle symptoms or differential diagnosis. Under these circumstances, triage ECG screening may be too liberally applied. This yields a large number of ECGs, all of which are then typically brought to a physician for review, almost always while that physician is engaged in another task. Skaugset describes data showing that emergency physicians are interrupted on average every 5–6 min and that this was associated with substantially decreased rates of task completion. Whether this leads directly to adverse outcomes is unknown, but it is likely not beneficial (except for the patient whose ECG is being read). A better strategy may be to apply more rigor to the decision to order a screening ECG and to ensure that the physician reading it is sufficiently familiar with high-risk patterns.

Training in ECG interpretation for EM residents is standardized but not consistently maintained and developed after graduation. The way to get better at consistently identifying subtle findings is to deliberately scrutinize a large volume of ECGs and to be curious about how they correlate with angiographic and clinical outcomes. Computer algorithms, at least at their current level of sophistication, are assistive tools that

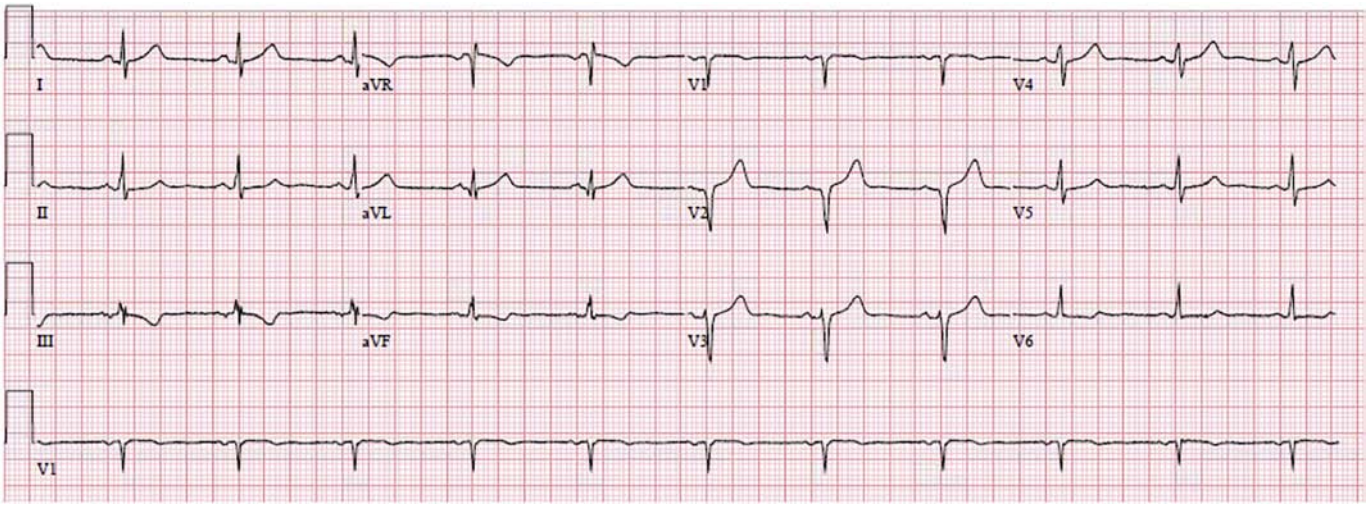

Fig. 2a. Computer "Normal" can also miss the subtly abnormal but potentially catastrophic, such as this 45-year-old man with acute, sharp, nonexertional left chest pain and left arm paresthesias. This ECG was taken approximately 45 min after onset of pain, which had been improving since then. The ECG shows ST elevation and a Q-wave in V2, subtle ST depression in III & aVF, a "down-up" T wave morphology in aVF, and subtle ST elevation in aVL.

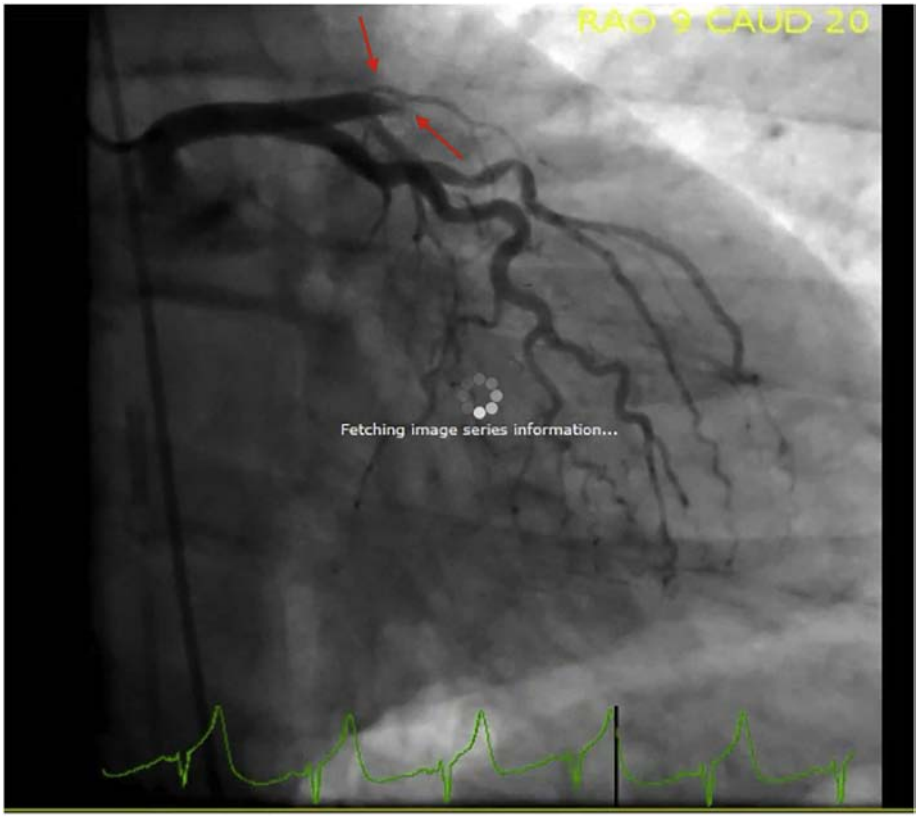

Fig. 2b. After fluctuating symptoms, negative initial troponin, and admission for observation, his pain returned and was followed by ventricular fibrillation cardiac arrest and successful resuscitation. Angiography revealed complete LAD occlusion.

cannot replace a skilled physician. To improve efficiency, it may be more valuable to refine the criteria for performing an ECG in the first place. Despite the plausible (but still speculative) association between task interruption and patient safety, there are other targets besides triage ECGs for reducing unnecessary distractions and their attendant risk. Meanwhile, physicians should take steps to develop their skills in detecting subtle signs of myocardial ischemia, and computerized interpretation algorithms should state "No abnormalities detected" rather than "Normal ECG". This combined approach is a more effective and durable way to benefit vulnerable patients and distracted physicians than simply trusting the computer's assessment of "Normal".

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