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COMMENTARY

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Should doctors replace machines in prehospital electrocardiogram interpretation?

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1 | INTRODUCTION

Prehospital activation of cardiac cath labs for potential ST-elevation myocardial infarction (STEMI) reduces total ischemic time and door-to-balloon (DTB) time and has become the standard of care in many industrialized nations.[1] At the same time, interventional cardiologists (ICs) routinely experience being woken at 2:00 a.m. only to call off a cardiac cath lab activation (CCLA) for an obvious false-positive electrocardiogram (ECG) in a patient without chest pain. False-positive activations occur frequently (23%–65%) with computer interpretation alone,[2] and would be expected to increase costs, staff and practitioner burnout, and patient morbidity from unnecessary procedural and anticoagulation risks.

In this issue of Catheterization and Cardiovascular Interventions, Faour and colleagues[2] from Liverpool hospital in Australia identified 1088 consecutive prehospital electrocardiograms (PH-ECGs) transmitted for possible STEMI CCLA. Paramedics were obligated to systematically transmit any ECG with a computer diagnosis of STEMI regardless of symptoms. ECGs were transmitted directly to the hospital and the mobile device of the on-call IC, who could discuss with the paramedics the options of prehospital CCLA or fibrinolysis or deferral of activation depending on the clinical presentation and whether the IC agreed with the interpretation. Among the 1088 PH-ECG transmissions that might have led to automatic CCLA in systems without IC input, there were instead 565 (52%) CCLA and 523 (48%) nonactivations in the authors' system.

Each ECG was blindly adjudicated by two cardiologists for STEMI or equivalents according to University of Glasgow ECG criteria (ST-segment elevation ≥1 mm in ≥2 contiguous leads, and STEMI equivalents including left bundle branch block, posterior infarction, and aVR elevation). The appropriateness of the CCLA decision was adjudicated after review of the patient's clinical presentation, ECGs angiograms, and troponin values. The authors judged the CCLAs as 97% appropriate and 2.7% inappropriate, while the nonactivations were 96% appropriate and 3.6% inappropriate (missed STEMI). Appropriate nonactivations were due to nondiagnostic ST-elevations (25%), artifact (14%), bundle branch blocks (26%), repolarization abnormalities (12%), among other causes.

In short, about half of the automated PH-ECG transmissions in this study were false-positives and would have resulted in unnecessary CCLA without the interpretation of the IC. With IC involvement, the rates of inappropriate CCLA and missed STEMI were both very low.

Prehospital CCLA, usually with PH-ECG alone, has been highly successful in reducing DTB time in most hospitals to less than 90 min and rightfully celebrated as an effective process improvement. However, reductions in DTB have not reduced mortality after STEMI[3] and PH-ECG activations are frequently false-positives. This study demonstrates that incorporating IC interpretation of the ECG and discussion with the paramedics before CCLA would reduce inappropriate activations at the risk of a few minutes of clinically insignificant delay.

2 | THE FUTURE OF AUTOMATED ECG READING

Within the medical technology innovation space, artificial intelligence is the new buzzword. Sun Microsystems cofounder Vinod Khosla has claimed that “machines will substitute [for] 80 percent of doctors in the future in a healthcare scene driven by entrepreneurs, not medical professionals.” Neural networks expert Geoffrey Hinton has said that it's “quite obvious that we should stop training radiologists” as image analysis algorithms will be superior to humans.[4]

At first glance, ECG interpretation should be a straightforward task for machine learning. The first automated ECG interpretation

system went into operation back in 1971 at the Glasgow Royal Infirmary and the first clinical databases for validation were established in 1974. Yet, the study by Faour et al.[2] demonstrates a large benefit from human IC overreading of the automated ECG. Does this mean that physicians are really 96%–97% accurate in STEMI ECG interpretation and machines only 50%?

While attractive to the Luddites among us, such a conclusion would be an oversimplification. Doctors did better because they had access to the clinical presentation, at least as communicated by paramedics, and could identify ECG STEMI mimics and artifacts in that context. Current ECG programs are programmed by humans to be highly sensitive and less specific to avoid the risk of a missed STEMI. A true machine learning algorithm would analyze the ECG in the context of components of the clinical presentation but would be limited to data fed to it by a human taking the history. Such a process would be impractically slow and lose the nuance that comes with human communication.

The question then is not whether machines and automation will replace physicians, but rather where machines can help humans provide better care. Automated ECG analysis is already faster and more accurate than cardiology trainees for basic and algorithmic measurements (heart rate, rhythm, axis, and intervals),[5] for screening large datasets, and for monitoring. Humans are better at quickly communicating and integrating a diverse set of data, making decisions in the context of uncertainty or a lack of data, and communicating empathy. While the accuracy of computer-generated ECG interpretations is expected to only improve, for the foreseeable future the role that the cardiologist plays in the diagnosis of a STEMI remains indispensable. Health systems that aim to provide the most comprehensively efficient, accurate, and compassionate care would benefit from implementing early cardiologist consultation in their STEMI activation protocols.

CONFLICTS OF INTEREST

Dr. Seto has received research grants from Philips, Acist, and Pfizer, is a speaker for Terumo, General Electric, and Janssen, and received consulting fees from Medicure and Medtronic. The remaining author declares no conflict of interest.

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