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Beyond the ST-segment in Occlusion Myocardial Infarction (OMI): Diagnosing the OMI-nous

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Abstract:

The ST-segment elevation (STE) myocardial infarction (MI)/non-STEMI (NSTEMI) paradigm has been the central dogma of emergency cardiology for the last 30 years. Although it was a major breakthrough when it was first introduced, it is now one of the most important obstacles to the further progression of modern MI care. In this article, we trace why a disease with an established underlying pathology (acute coronary occlusion [ACO]) was unintentionally labeled with a surrogate electrocardiographic sign (STEMI/NSTEMI) instead of pathologic substrate itself (ACO-MI/non-ACO-MI or occlusion MI [OMI]/non-OMI [NOMI] for short), how this fundamental mistake caused important clinical consequences, and why we should change this paradigm with a better one, namely OMI/NOMI paradigm.

Keywords:

Acute coronary syndrome, coronary occlusion, electrocardiogram, myocardial infarction, ST-segment elevation

Introduction

The ST-segment elevation (STE) myocardial infarction (MI)/non-STEMI (NSTEMI) paradigm has been the central dogma of emergency cardiology for nearly 30 years.[1] It has been widely accepted as the infallible indication of an acute coronary occlusion (ACO) or near-occlusion that necessitates and benefits from immediate reperfusion. The term STEMI established itself so firmly in our minds, as if the real disorder that we are looking for was an electrocardiogram (ECG) abnormality rather than the ACO itself. If the ECG does not show STE despite the subsequent angiogram showing an ACO, the STEMI/NSTEMI paradigm automatically accepts it as a NSTEMI, not a missed "STEMI." This highly presumptuous, yet widely accepted, claim with "no false negativity" is a quite uncommon, if not unique, diagnostic paradox in medicine.[2] As a consequence, it is falsely reassuring as if it is acceptable to let a patient actively have an MI under our supervision as long as there is no "diagnostic" STE on the ECG. Consequently, the validity of the established STEMI/NSTEMI paradigm started to be questioned, and the need for better paradigm has unavoidably risen.[3-5]

In this article, we trace why a disease with an established underlying pathology (ACO) was unintentionally labeled with a surrogate ECG sign (STE) instead of pathologic substrate itself (ACO-MI/non-ACO-MI or OMI/non-OMI [NOMI] for short), how this fundamental mistake caused important clinical consequences, and why we should change this paradigm with a better one, namely OMI/NOMI paradigm.

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What Is a ST-Segment Elevation Myocardial Infarction?

The notion that the STEMI patients would benefit from emergent reperfusion therapies comes from fibrinolytic studies done in the 1990s. In these trials, patients with suspected ACO, mostly without an evidence of STE or the presence of angiographic ACO being sought, had been randomized to fibrinolytics versus placebo and mortality had been taken as the outcome measure. Pooled data from these trials were studied in the seminal fibrinolytic therapy trialists' meta-analysis,[6] which showed an impressive reduction in mortality with a slightly better benefit in patients with (ambiguously and inconsistently defined) STE compared to general cohort.[1] This was an unparalleled revolution in cardiology which made "reperfusion medicine" the norm.

However, as many patients with no ACO, as well as normal subjects, have some STE on their ECGs, this vague STE needed to be defined better. Menown *et al*.[7] compared STE in normal subjects and patients with creatine kinase- MB (CK-MB)–diagnosed MI (again without referencing to ACO) and found that ≥2 mm STE in at least one of the anteroseptal leads or ≥1 mm in any of the other leads differentiates patients with MI from normal subjects. These results provided the basis for the first universal definition of MI.[8] Later, Macfarlane *et al*.[9] fine-tuned these criteria introducing age- and sex-based cutoffs, again comparing CK-MB–positive patients with normal subjects and without including any angiographic outcomes. In 2009, American Heart Association, American College of Cardiology Foundation, and Heart Rhythm Society[10] took these cutoffs that were originally developed to differentiate CK-MB–positive MI patients with normal subjects and surprisingly recommended their use in the differentiation of patients with STEMI and NSTEMI. These "STEMI criteria," namely (1) 1 mm STE in any two contiguous leads except V2 and V3; (2) STE in V2 and V3 on the basis of age and gender, where the following cut-points apply: ≥1.5 mm elevation in women regardless of age, ≥2.5 mm in men aged less than 40 years, and ≥2 mm in men aged 40 years and above, stuck and were repeated throughout the future guidelines, including the latest universal definition of MI consensus.[11]

Can a Non-ST-Segment Elevation Myocardial Infarction Still be OMI-nous ?

Although the current guidelines prudently advocate urgent (<2 h) invasive assessment in patients with persistent pain, hemodynamic compromise, acute heart failure, and/or arrhythmias to identify high-risk patients that may benefit from urgent revascularization,[12] it is not clear if this recommendation aims to identify high-risk patients or the patients with ACO. This distinction is highly relevant because high-risk patients may not necessarily benefit from urgent revascularization procedure despite having an increased short-term mortality; however, in the latter situation, urgent revascularization is expected to have a positive effect on the outcomes.

Observational studies indeed show that the current STEMI criteria miss approximately one-third of ACOs.[13-21] This suggests that, when STEMI criteria are not met, the physicians do not manage to identify the patients with ACO among all patients with undifferentiated persistent chest pain partly because it may be present in many other competing diagnoses.[1,2] Furthermore, STEMI criteria were shown to have only a prospective sensitivity of 21% and 49% for ACO when a computer algorithm and cardiologist evaluation were used, respectively.[22] Physicians across different specialties have poor accuracy and poor interrater reliability for detecting ACO[23] and cannot even agree on where and how to measure the STE.[24,25]

A high percentage of coronary occlusion at the 24-h angiogram was also seen in the randomized trials on acute management of NSTEMI comparing early and late intervention, even after the patients with persistent pain were excluded.[26-29] Therefore, the presence or the absence of persistent pain, hemodynamic compromise, severe heart failure, and/or arrhythmias are not reliable indicators for diagnosing or excluding an OMI; hence, clinicians need to put all lines of evidence together. Moreover, a recent real-life study showed that the clinicians generally do not elect to use urgent coronary angiography in the presence of these clinical parameters.[30]

On the other hand, the group of patients labeled as NSTEMI but having ACO is deprived of emergent reperfusion therapy, succumbs larger infarcts, and is roughly 1.5 times higher short- and long-term risk mortality.[16-21] Although no study compared early versus late intervention in patients with OMI, NSTEMI, observational evidence suggests that these patients significantly benefit from early intervention.[20,31]

What Is an Occlusion Myocardial Infarction?

OMI is an ongoing MI due to a total or near-total coronary occlusive process that necessitates acute reperfusion. It has no ECG, echocardiographic, or even angiographic findings in its definition (as coronary occlusion may spontaneously reperfuse at the time of the angiogram, so the absence of angiographic occlusion

does not exclude an OMI). It reminds the clinician that even if the ECG is nondiagnostic, the patient may still need acute reperfusion, and therefore, active search for further evidence should be warranted.

Three studies especially worth mentioning for supporting how such an endeavor seems rewarding. The DIagnostic accuracy oF electrocardiogram for acute coronary OCClUsion resuLTing in MI (DIFOCCULT) study[20] retrospectively compared OMI/NOMI approach with STEMI/NSTEMI paradigm. As expected, 28.2% of the patients initially classified as having NSTEMI were reclassified by the ECG reviewers as having OMI. This subgroup had a higher frequency of ACO, myocardial damage, and both in-hospital and long-term mortality compared to the NOMI group. The OMI/NOMI approach to the ECG had a superior diagnostic accuracy compared to the STE/NSTEMI approach in the prediction of both ACO and long-term mortality. Furthermore, early intervention in patients with OMI-predicting ECGs was associated with lower long-term mortality, whereas early intervention increased long-term mortality in patients with NOMI-predicting ECGs.

Another retrospective case–control study compared the accuracy of STEMI criteria versus structured OMI interpretation by expert ECG reviewers.[21] The OMI approach to ECG had significantly higher sensitivity (86% vs. 41% and 80% vs. 36%) for the detection of ACO compared to the STEMI criteria. The patients classified as NSTEMI, but OMI had a similar infarct size measured by peak troponin but greater delays to angiography compared with the patients classified as STEMI and OMI. Moreover, OMI approach diagnosed ACO earlier with a median of 1.5 h compared to STEMI approach.

Another study by the same group compared the STEMI/NSTEMI versus OMI/NOMI paradigms in 467 consecutive high-risk acute coronary syndrome patients.[31] Among the 108 patients with OMI, only 60% had any ECG fulfilling STEMI criteria. NSTEMI but OMI patients had similar infarct sizes and adverse outcomes as compared with the STEMI and OMI patients but were much less likely to receive emergent catheterization.

In summary, many studies indicated that the ECG has the capability of recognizing ACO with high accuracy beyond mere STE, including minor STE not fulfilling STEMI criteria, STE disproportionate to corresponding QRS-T-QT complex, unusual patterns with contiguous leads showing opposite ST-segment deviations, and some patterns not showing STE at all, but that a compilation of ECG tools will inevitably be necessary for diagnosis rather than using a single set of STEMI millimeter criteria.[32-35] The readers strongly advised to refer to our latest article which provides a step-by-step approach to OMI diagnosis.[33] Furthermore, the diagnosis of ACO is not limited to ECG. The use of other diagnostic tools, such as echocardiography,[36,37] computed tomography angiography,[38] and conventional angiography, should be considered when clinical suspicion is high.

Conclusion

The current STEMI/NSTEMI paradigm is imperfect and needs to be replaced by a better OMI/NOMI paradigm. Since the process of deciding on whether an ECG qualifies for acute reperfusion is a complex one, a tool set will inevitably be necessary for the diagnosis rather than using a single-point measurement of ST-segment. Furthermore, the clinicians should also be aware of the fact that OMI is not solely an ECG diagnosis. In patients with a high clinical suspicion, a careful follow-up and further diagnostic workup should be considered.

Author contributions
All by Emre Aslanger.

Conflicts of interest
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