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EDITORIAL

Beyond the ST Segment: Recognising Acute Complete Coronary Occlusion in Non-ST Elevation Myocardial Infarction

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Introduction

The dichotomous classification of acute myocardial infarction (AMI) into ST elevation myocardial infarction (STEMI) and non-ST elevation myocardial infarction (NSTEMI) has historically dictated clinical urgency for coronary angiography and revascularisation. STEMI is defined on the electrocardiogram (ECG) by ST elevation at the J-point in two contiguous leads, with either (1) ≥2.5 mm ST elevation in men <40 years, ≥2 mm in men ≥40 years, or ≥1.5 mm in women regardless of age in leads V2–V3, and/or (2) ≥1 mm ST elevation in other leads (Byrne et al, 2024). STEMI demands immediate reperfusion, whereas NSTEMI allows for angiography within 24–72 hours, if invasive management is planned. However, data suggest that up to 30% of NSTEMIs are caused by an acute complete coronary occlusion (ACCO), a pathology indistinguishable from STEMI in terms of treatment urgency (Tziakas et al, 2021). These patients, lacking 'diagnostic' ST elevation, are often denied urgent angiography and suffer worse outcomes (Hung et al, 2018). In routine clinical practice, the presence of ACCO as the underlying cause of an NSTEMI may go unrecognised if angiography is delayed, due to the high rate of spontaneous recanalisation, so the frequency of ACCO in patients without classical STEMI ECG may be underappreciated (Cox et al, 2006).

Several evidence-based ECG patterns beyond classical STEMI criteria can identify ACCO, but are not routinely recognised in clinical practice, particularly amongst non-cardiologists (Aslanger et al, 2020; de Winter et al, 2008). Integrating these findings into clinical protocols could reduce the substantial burden of preventable morbidity and mortality (McLaren et al, 2024). In this editorial, we outline key ACCO-associated ECG patterns that all physicians should be able to recognise.

NSTEMI, ACCO and Revascularisation Delay

Around 52,000 NSTEMI admissions were recorded in the United Kingdom over a 12-month period in 2023/2024 (National Cardiac Audit Programme, 2025).

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If an estimated 30% involved ACCO, approximately 15,000 patients had a completely occluded coronary artery, yet did not meet STEMI criteria. Despite clear guidelines, only 51% of patients with NSTEMI in the United Kingdom underwent angiography within the recommended 72-hour window, and 20% received no in-hospital angiography at all (National Cardiac Audit Programme, 2025). In patients with ACCO, this delay drastically reduces myocardial salvage and increases mortality risk (Montalescot et al, 2007).

Patients with NSTEMI tend to be older, with more comorbidities and complex coronary disease than their STEMI counterparts. The combination of delayed treatment, higher ischaemic burden, and increased physiological vulnerability contributes to poorer outcomes (Krishnamurthy et al, 2023). Meyers et al (2021) demonstrated that patients with ACCO but without ST elevation have higher in-hospital and 3-month mortality rates. Their study also revealed that newer ACCO-specific ECG findings significantly outperformed STEMI criteria in sensitivity and diagnostic accuracy, albeit at the expense of specificity.

Conversely, not all cases of NSTEMI with marked ischaemic changes on the ECG reflect an ACCO. For example, diffuse ST depression with reciprocal ST elevation in augmented vector right (aVR) is a classic pattern of subendocardial ischaemia and may result from a range of conditions, including multivessel coronary artery disease, left main stem stenosis, or non-coronary causes such as pulmonary embolism or global hypoxia. Importantly, subendocardial ischaemia does not localise on the ECG, whereas subepicardial ischaemia—more typical of ACCO—often does. Recognising the distinction between these ischaemic patterns is crucial, particularly in cases with ambiguous ECG findings. This highlights the need for nuanced ECG interpretation that integrates clinical context, rather than relying solely on rigid diagnostic thresholds.

Recognising ACCO: Key ECG Patterns

The 12-lead ECG is the cornerstone in ACCO identification, and several reproducible patterns have emerged beyond the conventional STEMI definition. Fig. 1 outlines a selection of these high-risk ECG patterns, summarised below:

• **Hyperacute T Waves (HATWs) (Fig. 1A)**: Early markers of ACCO, these disproportionately large, broad, bulky T waves display an increased 'area under the curve' relative to a standard T wave. Recently, Meyers et al (2025) proposed lead-specific thresholds to define HATWs based on T wave area to QRS amplitude ratio.

• **Precordial Swirl Pattern (Fig. 1A)**: Characterised by mild ST elevation in aVR and V1–2 (not meeting STEMI criteria), ST depression in V5–6, and an isoelectric ST transition in V3–4. This appears as a 'up-middle-down' progression through the precordial leads and is commonly associated with proximal left anterior descending (LAD) artery occlusion (Al-Zaiti et al, 2023).

• **De Winter T Waves (Fig. 1B)**: Up-sloping ST-depression (of at least 1 mm) preceding tall, symmetrical T waves, with reciprocal ST elevation in aVR $\geq$1 mm—

usually indicating proximal LAD occlusion (de Winter et al, 2008). This can occur in the setting of both right and left coronary circulation infarcts.

• **Smith-Modified Sgarbossa Criteria (Fig. 1C)**: Applicable in left bundle branch block or paced rhythms. Suggestive of ACCO if any of following are present: (1) $\geq$1 mm concordant ST elevation in $\geq$1 lead; (2) $\geq$1 mm concordant ST depression in $\geq$1 lead of V1–3; (3) proportionally excessive discordant ST elevation in $\geq$1 lead anywhere with $\geq$1 mm ST elevation (defined as $\geq$25% discordant ST elevation relative to the S wave) (Meyers et al, 2015).

• **Aslanger Pattern (Fig. 1D)**: Suggests a likely right coronary artery or left circumflex artery occlusion in the setting of multivessel disease, characterised by mild ST elevation in lead III and/or aVR, ST-depression in V4–6 with terminal T-wave positivity, and a ST segment in V1 more positive than in V2 (Aslanger et al, 2020).

• **New Bifascicular Block/Right Bundle Branch Block (RBBB)**: Often accompanied by RBBB-concordant anterolateral ST elevation and reciprocal inferior ST depression, indicating proximal LAD/left main coronary artery occlusion (Figueroa-Triana et al, 2021).

• **Subtle Anterior ST Elevation**: Where not meeting the voltage criteria for STEMI, subtle (1–2 mm) anterior ST elevation can still signify ACCO, but can be difficult to differentiate from normal variants. Scores such as that developed by Driver et al (2017) can be useful in screening these cases for ACCO.

Crucially, these patterns may not meet traditional STEMI criteria but are predictive of ACCO and adverse outcomes. Although individually rare, their collective prevalence makes them vital targets for recognition. Effective ECG interpretation in the context of ACCO diagnosis requires a thorough, holistic approach to the whole ECG beyond ST-segment height. Therefore, it is essential to assess for proportionality, local changes, patterns of ST-T change (morphology and distribution) and QRS width and height; often, secondary depolarisation abnormalities are followed by secondary repolarisation abnormalities that may present as a mimic of an occlusive pathology.

Notably, there are several ECG patterns that may falsely mimic ACCO, reinforcing the need for diagnostic vigilance. For instance, hyperkalaemia can produce ST elevation or QRS-T wave changes that closely resemble those seen in AMI. Hypertrophic cardiomyopathy may imitate an inferior myocardial infarction, while tachyarrhythmias can exaggerate or induce pseudo-elevated ST segments. Additionally, early repolarisation variants may demonstrate ST elevation without accompanying high-risk features of occlusive pathology—such as reciprocal ST depression, terminal QRS distortion, or disproportionate T-wave morphology. In such cases, relying solely on ST segment appearance may lead to diagnostic error. It is therefore essential to evaluate the ECG in conjunction with the clinical presentation, integrating features such as symptom pattern, haemodynamic status, and biochemical markers to distinguish true occlusion from mimics.

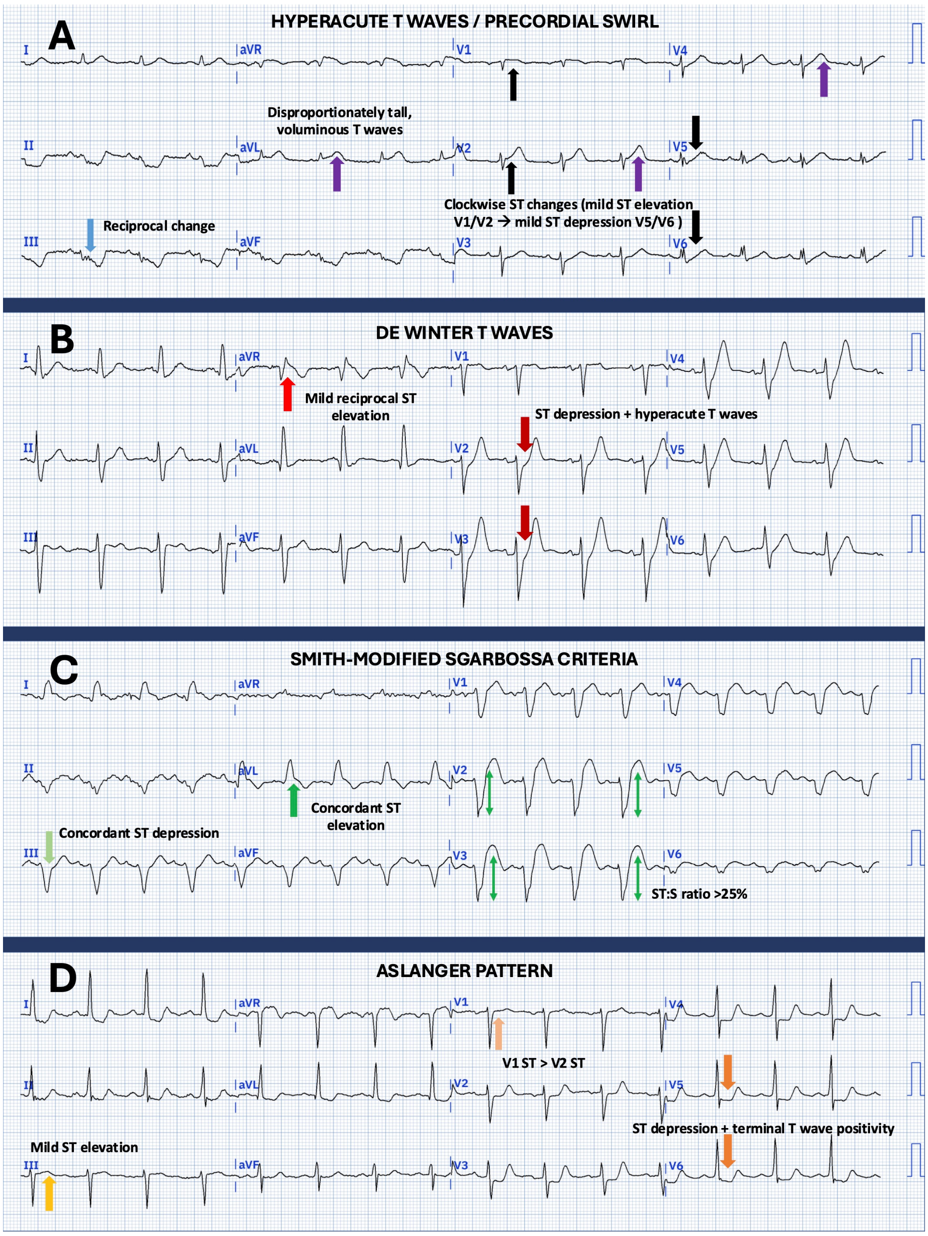

Fig. 1. Four electrocardiogram patterns consistent with acute complete coronary artery occlusion in the absence of contiguous ST elevation. (A) Anterolateral hyperacute T waves accompanied by a precordial swirl pattern (clockwise ST change through the precordial leads). The acute anterior wall infarct (attributable to a proximal left anterior descending artery occlusion) is reciprocated in the inferior leads with ST depression. (B) De Winter T waves (ST depression preceding a positively tall hyperacute T wave) seen in V1–5, reciprocated with elevation in augmented vector right (aVR), due to an acute left anterior descending artery occlusion. (C) Left bundle branch block with positive Smith-Modified Sgarbossa criteria. Early precordial ST:S ratio exceeding 25%, accompanied by concordant ST elevation in I and augmented vector left (aVL), with reciprocal ST depression inferiorly, due to a proximal left anterior descending artery occlusion. (D) Aslanger pattern with isolated mild ST elevation in III with diffuse subendocardial ischaemia (ST-depression in V3–6, I, II and aVL succeeded by a terminally positive T wave). Due to an acute left circumflex artery occlusion accompanied by a critical left main coronary artery lesion. Note: aVF, augmented vector foot.

Organisational Challenges in Improving ACCO Recognition

Additional clues to the presence of ACCO can often be obtained from echocardiography; however, in the UK, access to out-of-hours scanning is typically limited outside of centres with a resident cardiology registrar. Expanding echocardiography training among acute medical teams could help improve diagnostic certainty in these cases.

Increasing acceptance of ACCO cases for primary percutaneous coronary intervention would place additional pressure on emergency cardiac services, including the risk of prolonging call-to-balloon times for other STEMI cases and intensifying the workload for catheter laboratory on-call teams, many of whom operate on demanding 24-hour rotas. These operational implications must be considered when evaluating changes to standard primary percutaneous coronary intervention acceptance criteria. Nevertheless, the overall workload for interventional centres is unlikely to increase substantially, as most ACCO patients typically undergo inpatient coronary angiography during their admission regardless.

Conclusion

A significant proportion of patients suffering with AMI due to an ACCO do not meet STEMI criteria and are managed as NSTEMI, when managing as STEMI might be more appropriate. This may lead to delayed treatment and poorer outcomes. The current STEMI/NSTEMI paradigm lacks the sensitivity and accuracy required to identify all patients needing urgent revascularisation. There is now growing evidence for ECG markers of ACCO that fall outside traditional criteria, and failure to recognise these may risk preventable harm. Clinicians must be aware trained to interpret ECGs holistically, and practice guidelines should evolve to reflect a more nuanced understanding of occlusive myocardial infarction.

Key Points

- Around 30% of patients with non-ST elevation myocardial infarction have an acute complete coronary occlusion (ACCO)—the same pathology characterising ST elevation myocardial infarction (STEMI).
- Traditional STEMI criteria offer poor sensitivity and diagnostic accuracy for assessing ACCO.
- Several ACCO-specific electrocardiogram (ECG) patterns exist without diagnostic ST elevation and correlate with worse outcomes.
- General physicians should consider early discussion with cardiology colleagues if the ECG is suggestive of ACCO, regardless of ST elevation. Urgent revascularisation should be considered in such cases.

Availability of Data and Materials

Not applicable.

Author Contributions

JC, WAEP and MTM conceived this work. All authors contributed to drafting the manuscript and revising it critically for important intellectual content, and gave final approval of the version to be published. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

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