British Cardiovascular Society

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From Tracings to Thinking: How Cardiologists Learn ECG Interpretation and What Medical Education Often Misses

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Take Home Messages

- ECG interpretation is a complex cognitive skill, not an intuitive ability acquired through passive exposure.
- Current training models often fail to intentionally support the transition from novice to expert, leading to variable competence and persistently imperfect accuracy, even at consultant level.
- This commentary review highlights how effective ECG education depends on structured, longitudinal design with protected time, explicit feedback, harmonised standards, and visible expert reasoning.
- ECG training requires deliberate integration of pattern recognition, electrophysiological understanding, and clinical reasoning.

Introduction

The way cardiologists learn to interpret electrocardiograms (ECG) is often assumed to be intuitive or acquired through passive exposure over time. ECG interpretation is a complex cognitive skill that requires the integration of pattern recognition, physiological understanding, and clinical context in an intentional learning environment. Despite its central role in cardiology and acute care, the educational process underpinning ECG interpretation is often under-articulated, methodologically inconsistent, and highly variable in depth depending on training programme philosophy, resources, and experience. (1)

ECG interpretation

Early in training, resident doctors are commonly taught ECG interpretation using rigid and stepwise frameworks. These approaches are useful for developing foundational competence and reducing cognitive load, especially during emergency scenarios, (3) but they rarely reflect how experts interpret ECGs in practice. Experienced cardiologists rely on rapid pattern recognition, underpinned by a robust understanding of electrophysiological mechanisms and clinical context.

This expertise is further refined through repeated exposure and feedback, with analytical reasoning used deliberately to resolve uncertainty and interpret atypical findings.

However, even with increasing levels of experience, ECG interpretation accuracy, defined against a single criterion-standard interpretation for each ECG item, remains imperfect, with reported median accuracies of 42.0% for medical students, 55.8% for resident doctors, 68.5% for non-cardiologist, and 74.9% for cardiologists. (4) By contrast, a UK study of paediatricians reported a baseline accuracy of 61.5% for initial ECG interpretations, increasing to 73.3% following use of a structured educational resource, independent of prior ECG training. (5) Similarly, in a population-based atrial fibrillation screening study, cardiologists interpreting single-lead ECGs demonstrated only moderate inter-rater diagnostic agreement, highlighting variability in expert interpretation even in relatively focused clinical tasks. (6)

A persistent challenge across healthcare systems is how to support the transition from novice to expert in environments increasingly shaped by service pressures, workforce variability, and time constraints (Figure 1). ECG learning is frequently embedded in service-heavy environments, characterised by time pressure and inconsistent feedback, allowing errors to go uncorrected and learning to become opportunistic rather than deliberate. In an increasingly heterogeneous medical workforce, assumptions about prior knowledge further highlight the need for structured, harmonising educational sessions across training cohorts. (7) In response, several training programmes internationally have intentionally redesigned their educational structures to bridge this gap between service delivery and skill development.

In the United States and Canada, protected faculty-led ECG case-discussion, competency-based assessment frameworks, and longitudinal curricula linked to entrustable activities are embedded within training programmes. (7,8) In Australia, New Zealand, and parts of Europe, structured workshops, curated ECG libraries, and simulation-integrated arrhythmia modules provide more standardised exposure. (9) Collectively, these approaches demonstrate that deliberate curricular design, rather than passive clinical exposure alone, can strengthen the development of ECG competence.

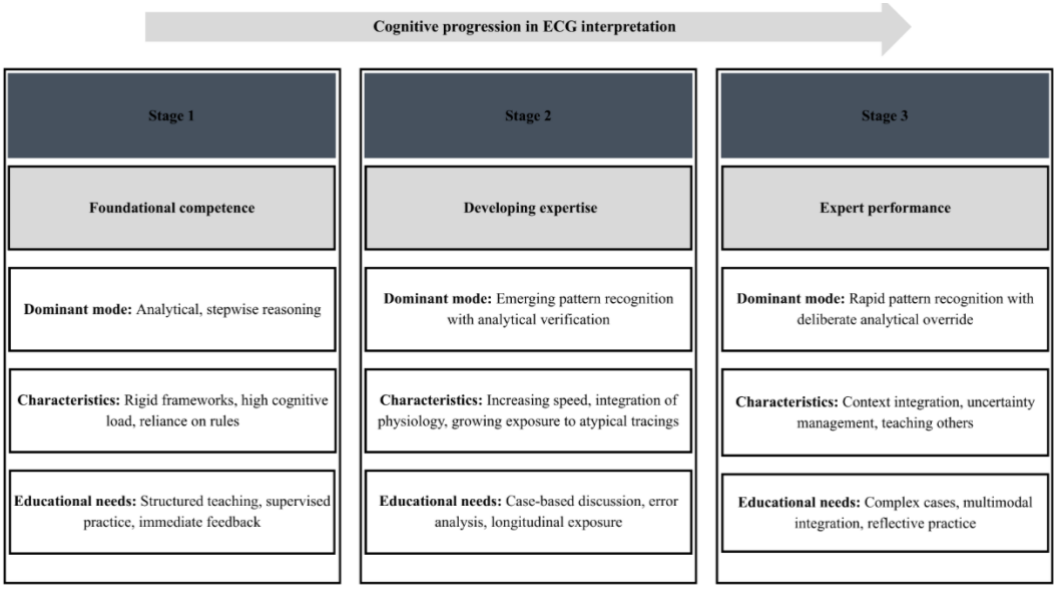

Figure 1. Cognitive progression in ECG interpretation.

Recognised evidence-based components of a successful ECG learning environment

Intentional ECG education requires protected time and a methodologically structured approach. Longitudinal exposure, near-peer teaching, active learner–lecturer interaction, vector-based interpretation, case-based discussion, and clinical integration have all been identified as key components of effective ECG curricula. (7,10–13) Qualitative and mixed-methods studies indicate that, in unstructured environments, ECG learning becomes opportunistic and task-oriented. As a result, workplace-based assessments are perceived as variable and often superficial, feedback is inconsistent, and residents report reliance on self-directed exposure rather than deliberate practice. (14-18)

ECG training in the United Kingdom (UK)

Cardiology training in the United Kingdom has faced increasing challenges driven by the expanding need for generalist skills alongside escalating service provision pressures. (19) Although there are some established opportunities to get ECG teaching from experienced cardiologists during national meetings (e.g. British Cardiovascular Society Annual Conference) and deanery training sessions, local training remains heterogeneous due to variable levels of local

expertise and the systemic challenges already described. Consequently, most residents rely primarily on self-directed learning of variable depth, supplemented only by occasional senior-led feedback and teaching. This results in varying levels of ECG interpretation expertise by the end of training.

Any meaningful reform of ECG teaching in training must move beyond vague calls for more education and instead focus on structure, accountability, and clearly defined progression. At a curriculum level, ECG interpretation should have clearly defined, stage-specific expectations across training years (**Figure 2**), aligned with the existing *Management of Cardiac Arrhythmias* capabilities outlined in the UK Cardiology Curriculum (20). Early residents, such as those at ST4 level, should demonstrate a solid understanding of cardiac electrophysiology and the conduction system, alongside reliable recognition of common ECG abnormalities. More advanced residents pursuing electrophysiology training should show fluency in complex arrhythmias, conduction disease, inherited syndromes, and integration of ECG findings with imaging and invasive data. These milestones should be nationally harmonised and assessed through serial, standardised testing rather than relying on workplace-based assessments, which are too variable to guarantee competence.

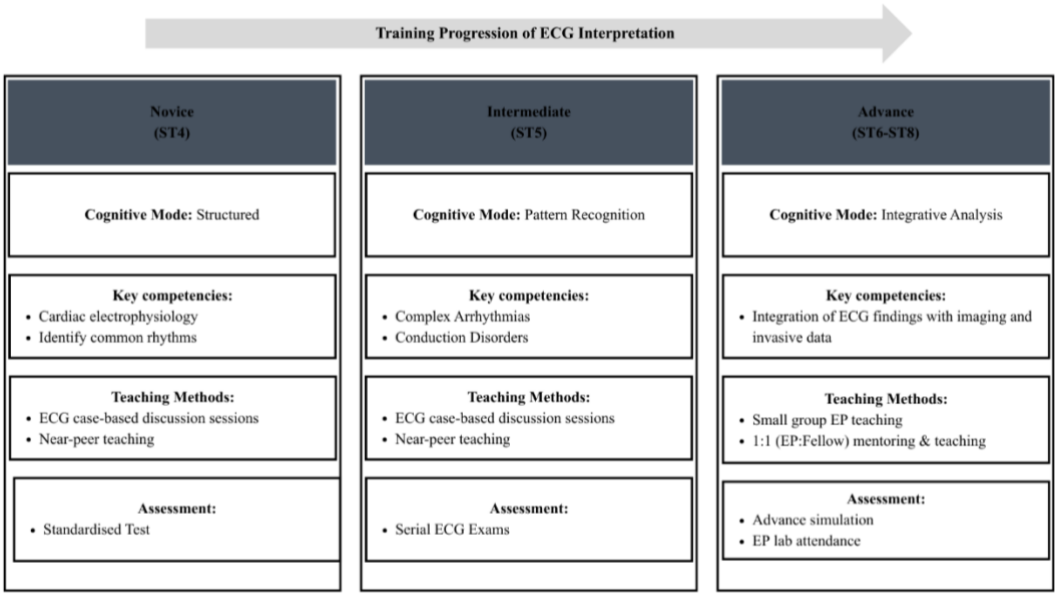

Figure 2. Stages of ECG Competency in Cardiology Training.

At a programme level, ECG teaching must be longitudinal and protected. This does not necessarily require extensive new resources, but it does require deliberate scheduling. Regular consultant-led small-group ECG and cardiac physiology teaching sessions, using curated and clinically relevant tracings, should be embedded into training timetables across the country. Sessions should prioritise diagnostic reasoning, uncertainty management, and error analysis. Digital ECG libraries shared across deaneries could standardise exposure to uncommon but high-risk pathologies. In addition, emerging artificial intelligence tools that enhance ECG interpretation by automating pattern recognition and providing diagnostic feedback may serve as adjunctive educational resources, helping residents consolidate interpretative skills in real time while exposing them to a wider range of ECG phenotypes. AI-enabled ECG systems have been shown to improve diagnostic precision and expand interpretative capabilities beyond traditional analysis. (21) Near-peer teaching should be formalised. Senior residents with demonstrated competence can lead supervised workshops for junior colleagues, reinforcing their own expertise. However, this should complement, not replace, direct consultant involvement.

At the level of individual trainers, ECG teaching should be regarded as a professional responsibility embedded within daily clinical work. During ward rounds, clinics, and on-call shifts, consultants should verbalise their interpretative reasoning. Expert cognition must be made visible, including how patterns are recognised, how differential diagnoses are prioritised, and how ambiguity is resolved. Without this transparency, residents are left to reverse-engineer conclusions without understanding the underlying reasoning.

Conclusion

How cardiologists learn to interpret ECGs reflects broader tensions within medical education between service provision and skill development. If ECG interpretation is left to be learned solely through service delivery, variability in competence is inevitable. By contrast, recognising ECG interpretation as a high-level cognitive skill that warrants deliberate educational design is essential for producing cardiologists who are not only accurate, but confident and adaptable in their clinical decision-making, irrespective of the diagnostic tools available, including artificial intelligence.

Disclosures

The author has no relationships relevant to the contents of this paper to disclose.

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