Understanding the ECG

A comprehensive 3-day course in ECG interpretation

Derek Rowlands and Philip Moore

THE BACKGROUND

The electrocardiogram has been in clinical use for over 100 years. It is the investigation of first choice in patients presenting with chest pain, dizziness, syncope or palpitation. It is remarkable that, even after 100 years of use, it is **still an absolutely essential part of any comprehensive cardiovascular assessment**, whether that assessment is in relation to the evaluation of a possible acute or chronic cardiovascular condition or is part of a screening procedure.

The 12 lead ECG is an essential part of any assessment of the cardiovascular system

Systematic, formal training in electrocardiographic interpretation in this country has been, and remains, virtually non-existent. Ad hoc courses given by Dr. Rowlands to medical students, to junior hospital doctors, to ITU nurses, to technicians and to general practitioners over many years have been very well attended, a fact which may or may not reflect the perceived value of the courses but which most certainly demonstrates the clear and massive need for teaching in this field. The need is not confined to these groups, but applies to medical students, A&E nurses, ambulance personnel, A&E consultants and consultant general physicians, personnel involved in medical screening services and in occupational health.

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General Practitioners have often in the past relied on their hospital colleagues to provide and to interpret electrocardiograms. This is no longer a realistic option. The primary care situation has evolved considerably in recent years. The majority of GP practices now have their own ECG machines and both patients and primary care trusts expect practices to provide a diagnostic ECG service. Currently this service is often dependent on one member of the group practice. Since he or she is inevitably considered by colleagues to be "the expert", mistakes in interpretation often go unnoticed and unchallenged, with the result that the same mistake is likely to be made on the next occasion. Automatic computer interpretation of the record helps to some extent but these systems do make errors and an automatic analysis which is incorrect is unlikely to be challenged unless the doctor has a firm grasp of basic electrocardiography, which alone would give the necessary confidence to "challenge the computer". Many General Practices in recent years have received funding for the purchase of ECG machines but we are not aware of any matching support for training in ECG interpretation. It must be recognised that o*nce a record has been taken or obtained, the general practitioner has acquired a responsibility in relation to the handling of the ECG data* and he/she is far less likely than doctors in hospital to have access to help from colleagues competent in the field. Any doctor acting as a result of an incorrect ECG interpretation obtained by automatic computer-based analysis may well still be considered to have at least a partial responsibility for any consequences of the error.

**once a record has been taken,
the doctor has acquired a responsibility**

Specialist Registrars and Senior House Officers necessarily have to interpret electrocardiograms in the course of their everyday practice. Typically their "training" consists of the hasty review of a simplified text and subsequent informal consultation with sympathetic colleagues. With the drive for earlier intervention in acute ischemic syndromes (most pressingly in respect of thrombolysis but, in those hospitals with, or with access to, interventional centres, also in respective of primary angioplasty) early recognition of significant S-T segment changes and of cardiac arrhythmias (both tachycardias and conduction disturbances) is increasingly important.

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and of cardiac arrhythmias is increasingly important.**

Intensive care and A&E nurses tend to have a reasonable working knowledge of the common arrhythmias but even in this area they are often unsure. In general they have little or no significant knowledge of the morphological aspects of the ECG. These nurses are a very highly motivated group of healthcare workers. They are usually denied access to anything other than very rudimentary teaching in the reading of ECGs despite the very clear professional need for, and their own powerful desire for, formal and effective instruction.

Cardiology technicians are probably the group most likely to have had some formal training in ECG interpretation. Many will have specialised knowledge (for example of pacemaker electrocardiography) but the majority would welcome further training, particularly of a structured and logical kind.

Consultant General Physicians have, in the past, been relied upon to provide an authoritative opinion on ECGs undertaken in hospital practice. Members of this group of doctors have rarely received any formal training in the subject and the majority have (relatively successfully it should be said) provided a diagnostic service using a pattern-recognition approach. Such a system of diagnosis will give the correct answer in many cases but is not reliable and can never solve the borderline case (in respect of which criteria for normality and for individual abnormalities are required). These matters are particularly important in relation to the diagnosis of acute myocardial ischaemia and infarction and of broad QRS complex tachycardias, but they also apply to the diagnosis of narrow QRS complex tachycardias and of conduction disturbances. With the increasingly consultant-based as opposed to the consultant-lead approach to acute medicine and with the rapidly evolving changes to the management of acute coronary syndromes, the need for the consultant physicians to have training in a reliable system of electrocardiographic interpretation has never been higher.

Occupational physicians and **doctors involved in screening programmes** need to have the confidence in ECG diagnosis which can only come from a clear understanding of the subject and a logical, systematic approach to diagnosis. The ability to make several common diagnoses using a pattern recognition approach is an unreliable and unsatisfactory basis for accepting professional responsibility.

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A & E Consultants share the same problems and responsibilities as consultant general physicians but their need for a reliable, logical system of ECG interpretation is even more acute since they are always in the "front line" in relation to emergencies.

Ambulance personnel have an increasing role in, and therefore an increasing responsibility for, the initial management of actual or possible cardiac emergencies. They are often the first professionals called upon to assess and to manage acute clinical situations, many of which pose the threat of early morbidity or mortality. Their actions in the first few minutes can have a profound effect on the eventual outcomes. They need to be competent in the recognition both of morphological and of rhythm abnormalities in the electrocardiogram.

Medical students have in the past hardly ever received any formal training in electrocardiography and the current crowded curriculum leaves even less room for this than formerly. With the advance of problem based learning it is even less likely that formal instruction in ECG interpretation will be available (or even permitted). From "day 1" of their house jobs, however, they are likely to be faced with the need to understand the electrocardiogram. Those who desire to avail themselves of the formal, didactic instruction, which these courses undoubtedly provide, should surely not be denied the option.

THE OBJECTIVES

The prime objectives of the course are to facilitate the understanding of, and to permit the reliable recognition of (i) the normal ECG, (ii) morphological abnormalities of the ECG and (iii) rhythm abnormalities, using a logical, systematic assessment.

The normal ECG. The single most important conclusion to reach about an ECG recording is whether it is completely within normal limits (which does not, of course, preclude the possibility of a clinically significant cardiac abnormality) or whether it shows some abnormality. To recognise and to define a specific ECG abnormality (e.g. left bundle branch block) requires a relatively small amount of information and is an easily achieved objective. To recognise and to define a normal ECG (with all its infinite possible variations) is much more challenging and requires a great deal of learning and understanding. This self-evident fact is ignored in most texts on the subject, which give little or no attention to the recognition of a normal recording. This course devotes one whole day to the normal ECG. Confidence developed in the recognition that a record is "within normal limits" enormously facilitates the subsequent understanding of specific abnormalities.

The single most important conclusion to reach about an ECG is whether or not it is within normal limits

Morphological abnormalities. Abnormalities of the shape and/or dimensions of the various components of the ECG (P waves, QRS complexes, S-T segment, T waves, U waves) provide very useful information about structural abnormalities of, or functional or metabolic damage to, the myocardium (atrial and ventricular).

Rhythm abnormalities. The ECG is the only practically available method for recording and analysing abnormalities of cardiac rhythm and conduction.

THE COURSE DESIGN

The 3-day course. The course has been specifically designed to facilitate understanding, learning, retention and subsequent clinical reliability. The key to successful learning is prior understanding. When the mechanism of any given ECG change is understood it is easy to retain the criteria for that diagnosis. The first day of the course deals with the normal ECG, the second day deals with morphological abnormalities and the third day with abnormalities of the cardiac rhythm. The emphasis is on **explanation of the way in which the normal and abnormal appearances arise**, in order to facilitate understanding and retention.

When the mechanism of any given ECG change is understood it is easier to retain the criteria for that diagnosis.

The course books form an essential part of the educational process. One book is provided for each day of the course. Virtually all of the visual material presented in the course appears in these course booklets. Delegates do not need to take notes, for the content of all the presentations appears in the course books. In total, the three volumes involve over 200 pages with over 280 illustrations. Taken together the three volume handouts effectively form a textbook of electrocardiography.

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In addition to the three volume handouts, four double-sided laminated guides are provided with the systematic approach to ECG interpretation and to the recognition of the most important morphological and rhythm abnormalities. These are invaluable subsequently for guiding ECG interpretation in the clinical situation.

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Interactivity. The course is at all times interactive, and delegates are encouraged to interrupt whenever they experience any difficulty in understanding a concept or in agreeing with the presenters. The atmosphere is friendly and every effort is made to ensure that there is no sense of stress or intimidation. The objective of facilitating learning and understanding cannot be achieved if delegates are made to feel insecure or inadequate. It is essential that complete rapport between presenters and delegates is both achieved and maintained.

Practical ECG interpretation. The emphasis during the three days is on understanding the normal and abnormal ECG and on learning the criteria for normality and for specific abnormalities.

Certification. Delegates who have attended all 3 days of the course will receive a certificate of attendance**.**

THE COURSE CONTENT

DAY1: The normal ECG.

History of electrocardiography

Indications for ECG recording

- For the diagnosis of overt or suspected cardiovascular disease
- For following the progress of patients with cardiovascular disease
- For persons with risk factors for heart disease
- As part of cardiovascular assessment prior to non-cardiac surgery in patients with known or suspected cardiac problems
- For patients with known or suspected metabolic or systemic conditions
- In the assessment of risk in such specialised occupations as pilot, train driver, HGV driver etc
- In the assessment of young people before entering sports requiring extreme levels of exercise
- As part of a general screening procedure (although it should be noted that it contributes little to assessment in young patients with no risk factors)

Basic principles

- Basic electrophysiology
- The cardiac cell membrane
- Resting membrane potential
- Depolarisation and repolarisation
- The action potential
- The propagated action potential

Cell types within the heart

- Pacemaking and conducting tissue
- Myocardial cells

Basic waveforms of the ECG (P, QRS, ST, T and U waves)
Basic form of the surface ECG
QRS waveform Nomenclature
Vector properties
The conventional 12 ECG leads
- Six limb leads
  - Three bipolar limb leads
  - Three unipolar limb leads
- Six precordial leads

The frontal plane QRS axis - meaning of
The frontal plane QRS axis – determination of
The frontal plane QRS axis – clinical and electrocardiographic significance of
Technique of ECG recording
- Proper electrode placement (precordial leads and limb leads)
- Consequences of incorrect lead placement
- Correct standardization
- Proper frequency response and calibration
- Proper paper speed
- Effect of age, weight and body build
  - Muscle tremor
  - Baseline drift

Normal morphology of P waves, QRS complexes, S-T segments, T waves and U waves
- Morphology of the normal QRS complexes in the precordial leads
- Clockwise and counter clockwise cardiac rotation
- Vertical, horizontal and intermediate heart positions
- Dimensions of the normal QRS complexes in the precordial leads
- Precordial S-T segments
- Precordial T waves
- Precordial P waves
- Recognition of abnormal q waves in limb leads
- Recognition of abnormal S-T segments in limb leads
- P waves in limb leads
- U waves

Systematic approach to ECG interpretation Steps 3 and 4 of the 4-step system
Examples of normal and abnormal ECGs interpreted by the systematic approach

DAY 2: Morphological abnormalities.
Left ventricular hypertrophy
- QRS changes
  - Sokolow-Lyon index
  - Cornell voltage criteria
  - Romhilt-Estes criteria
- S-T segment changes
- T wave changes
- Effect on axis

Right ventricular hypertrophy
- QRS changes
- Axis shift
- S-T segment changes
- T wave changes

Biventricular hypertrophy
Right atrial hypertrophy
Left atrial hypertrophy
Right bundle branch block
- QRS changes
- S-T changes
- T wave changes
- Effect on axis

- Impact of presence of RBBB on ECG interpretation

Left bundle branch block
- QRS changes
- S-T changes
- T wave changes
- Effect on axis
- Impact of presence of LBBB on ECG interpretation

Systematic approach to ECG interpretation Steps 2, 3 and 4 of the 4-step system

The hemi-blocks
- Left anterior hemi-block
- Left posterior hemi-block

ECG changes in ischaemic heart disease
- Q wave and non-Q wave infarction
- QRS changes of infarction
- S-T segment changes of infarction
- T wave changes of infarction
- Time sequence of ECG changes of infarction – ageing an infarct
- Location of infarction
- Reciprocal changes in infarction
- Non-specific changes in infarction
- Acute ischaemic syndromes
- Reliability of the ECG in diagnosis of infarction
- Reliability of ECG in excluding infarction
- Pitfalls in the electrocardiographic diagnosis of infarction

The exercise ECG
- History of exercise electrocardiography
- Current usage of the exercise ECG
- Normal ECG changes during exercise
- Criteria for abnormality of the ECG during exercise
- Sensitivity and specificity of exercise ECG changes in the diagnosis of coronary disease
- Risks of exercise electrocardiography
- Contraindications to exercise electrocardiography
- Interpretation of the exercise ECG

Ventricular pre-excitation
- Effect on ECG morphology
- Relevance to cardiac arrhythmias
- Recognition of ventricular pre-excitation from the 12 lead ECG

Systematic approach to ECG interpretation Steps 1,2, 3 and 4 of the 4-step system

Miscellaneous abnormalities
- Hypokalaemia
- Hyperkalaemia
- Hypocalcaemia
- Hypercalcaemia
- Hypothyroidism
- Pericarditis
- Pericardial effusion
- Cerebrovascular accidents
- Pulmonary embolism

DAY 3: Normal rhythm and cardiac arrhythmias.

Sinus rhythm
- Sinus arrhythmia
- Sinus bradycardia
- Sinus tachycardia
- Sinus pause or arrest

"Ectopic" beats

"Premature" beats

"Escape" beats

Atrial premature/ectopic beats
- Atrial premature beats

- Atrial ectopic beats
- Blocked atrial premature beats

Atrial tachycardia
- Atrial tachycardia with atrioventricular (AV) block

Atrial flutter
Atrial fibrillation
Any atrial rhythm (ectopics beats, tachycardia, flutter or fibrillation) with aberration
Junctional premature beat s
Junctional escape beats
Junctional rhythm
Atrioventricular nodal re-entrant tachycardia (AVNRT)
Atrioventricular tachycardia (AVRT)
Wolff Parkinson White syndrome
Supraventricular tachycardia (not otherwise identified)
Ventricular premature beats
Ventricular ectopic beats
- Uniform ventricular ectopic (or premature) beats
- Multiform ventricular ectopic (or premature) beats
- Interpolated ventricular premature beats
- Coupled ventricular premature beats
- Ventricular couplets
- Ventricular triplets
- R-on-T ventricular ectopic beats

Idioventricular rhythm
Non sustained ventricular tachycardia
Wide QRS tachycardia
- Supraventricular tachycardia with pre-existing bundle branch block
- Supraventricular tachycardia with functional aberrant intraventricular conduction
- Supraventricular tachycardia with pre-excitation
- Ventricular tachycardia

Ventricular parasystole
Ventricular tachycardia
- Fusion beats
- Capture beats
- Ventriculoatrial dissociation
- Ventriculoatrial conduction

Ventricular flutter
Ventricular fibrillation
Torsade de pointes
Reciprocal (echo) complexes
Atrioventricular conduction abnormalities
- First degree AV block
- Second degree AV block Möbitz Type I (Wenckebach)
- Second degree AV block Möbitz Type II (Möbitz)
- Complete (third degree) AV block
- High grade AV block

Atrioventricular dissociation
Logical Approach to rhythm analysis

THE COURSE PRESENTERS

Derek Rowlands is Honorary Consultant Cardiologist at the Manchester Heart Centre and Consultant Cardiologist at the Alexandra Hospital in Cheadle. He was formerly Consultant Cardiologist at the Manchester Heart Centre and Lecturer in Cardiology at the University of Manchester. He has given over 100 3-day courses in electrocardiography for General Practitioners. He is the author of "Clinical Electrocardiography" and has written the chapter on electrocardiography in all four editions of the Oxford Textbook of Medicine. His film on the normal and morphologically abnormal ECG won first place at the Sixth Biennial John Muir Medical Film Festival in 1986. He served for 15 years as sole editor of "Recent Advances in Cardiology" and for 5 years he was co-editor (with Professor Doug Zipes from Indianapolis)

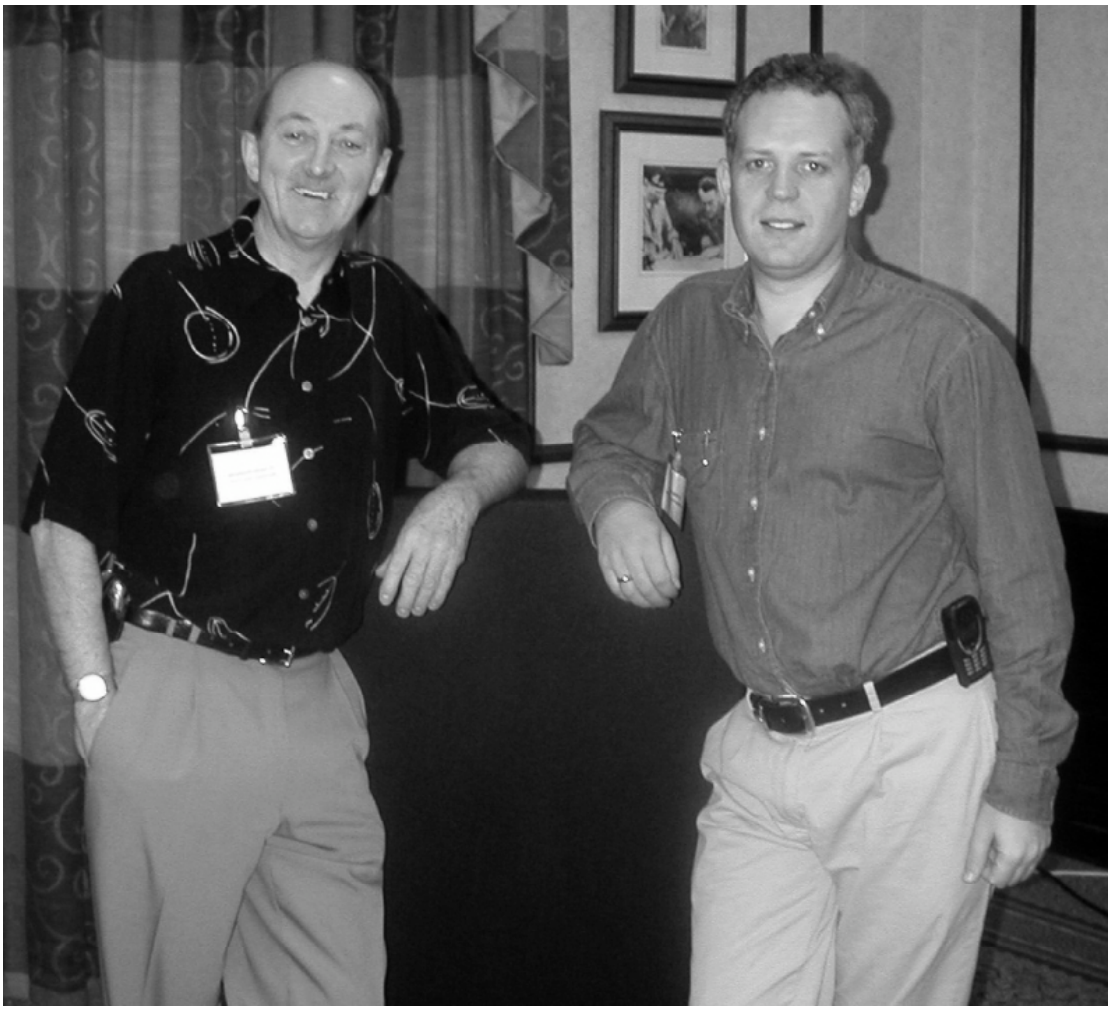
of “Progress in Cardiology”. In all, he has published 13 books, 5 as sole author, 1 as co-author and 7 as editor or co-editor. He has extensive experience in teaching the ECG to general practitioners, to nurses, to medical students, to technicians and to doctors at all levels of hospital practice.

Philip Moore is currently SpR in cardiology, on the NW Thames rotation. He was formerly a GP principal in St Albans for 4 years and prior to that completed a PhD in the department of Medicine at the University of Manchester/ Manchester Royal Infirmary. During his time as a GP he was CHD (coronary heart disease) lead for his practice and during his final year in primary care was CHD lead for the St Albans and Harpenden PCT, sitting also on the PCT professional executive committee (PEC). He has extensive teaching experience both in primary and secondary care and believes that with the recent extensive progress in the treatment of heart disease, there is a great need for high quality ECG teaching, based on a firm understanding of the principles of electrocardiography.

THE COURSE MATERIALS

The course is extensively illustrated throughout with varying audiovisual techniques designed to maximise understanding and to minimise delegate fatigue. Each delegate receives a comprehensive, hard copy handout so that note taking is eliminated or minimised. Most of the examples shown are presented in the handout.

We look forward to meeting you on the course.



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