Regular Review

Lessons from ambulatory electrocardiography

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In the 1950s Norman "Jeff" Holter, the American physicist, developed and gave his name to the technique of recording physiological signals from ambulant patients.[1] Holter monitoring has now come to be synonymous with ambulatory electrocardiography. In hospital practice the term ECG (electrocardiogram) taping is used, often with the prefix 24 hours to indicate the usual duration of the record. Ambulatory electrocardiography is the preferable term, however, because it covers variations in the way electrocardiographic signals are recorded (for example, by radiotelemetry or through the telephone rather than, as is usual, on to a tape cassette) and those monitors that are geared to record only when the patient experiences symptoms and then triggers the "event recording" button on the machine.

The commonest problem in interpreting ambulatory electrocardiographic records is recognising the signals that are due to artefact generated from poor contact between the skin and the recording electrode. Most artefacts are easily identified by their high frequency but others mimic arrhythmias such as ventricular tachycardia. Machine artefacts may also mislead—for example, slowing of the cassette may erroneously suggest bradycardia. Thus the first lesson of interpreting the results of ambulatory electrocardiography is to be wary of findings which do not fit with the clinical picture. It is also important to appreciate the extent to which electrocardiographic recordings vary in otherwise normal people, the poor correlation between the symptoms and arrhythmias, the changes that may lead to sudden death, and the signs of occult ischaemia.

Normal variation

A normal person may be defined as someone who has not been adequately investigated. Apply this aphorism to ambulatory electrocardiography and it becomes apparent that if anyone is monitored carefully sooner or later an extrasystole or pause is recorded. So what is normality? Clarke and colleagues examined 101 volunteers. Fifteen were excluded because of probable medical abnormalities but on the ambulatory electrocardiograms of the remaining 86, 10 had disturbances of rhythm which at the time were widely believed to be of "serious prognostic significance."[2]

Many hundreds of apparently normal people have been studied since then,[3] and our ideas of normality have changed. Bradycardias are common in young people, especially at night, and in a study of 50 medical students 12 had sinus rates of 40 a minute or less; three had second degree atrioventricular block.[4] Sinus pauses, first degree atrioventricular block, and nodal escape rhythms are not unusual and may be regarded as normal in youth. Sinus pauses should excite suspicion in older people, however, and should never exceed 2·5 seconds at any age.[3] Complete heart block as an unexpected finding has been found only once in a study of 722 people.[3]

Atrial extrasystoles are common and are not related to age. But runs of atrial extrasystoles become increasingly prevalent with age, and paroxysmal atrial fibrillation is an occasional finding in normal people over the age of 50. Ventricular extrasystoles are rare in schoolchildren,[5] but their prevalence increases with age to reach 75% in people aged 60-79.[6] They are also more frequent and complex in older people and in one study five out of 260 asymptomatic people over the age of 40 had episodes of ventricular tachycardia.[6]

Do these findings merely indicate occult heart disease? Common sense suggests not, and this view is supported by studies such as that of Kennedy and colleagues, who investigated 25 people with complex ventricular extrasystoles and found that only six had coronary artery disease.[7] Long term follow up of asymptomatic people with ventricular extrasystoles has confirmed that such individuals have a good prognosis.[8] Thus ventricular extrasystoles may merely be an indicator of aging in the way that high vagal tone may result in bradycardia in younger people.

Symptoms and arrhythmias

Some people tolerate serious arrhythmias without comment, others report every extrasystole, and it is because a person's awareness of his heart beat is so unpredictable and arrhythmias are so common that only those that give rise to symptoms should be considered to be the cause of the patient's complaint. A diary is, therefore, an essential adjunct to ambulatory electrocardiography. Without it misinterpretation is easy. More than one cardiac pacemaker has been mistakenly implanted for the treatment of dizzy spells in a patient with a physiological bradycardia. Conversely, a normal electrocardiogram and a blank diary cannot be taken to exclude paroxysmal tachycardia.

Sadly only a minority of ambulatory electrocardiograms give clear cut answers. In 165 patients complaining of palpitation a correlation between symptoms and arrhythmia was obtained in only 43.[9] This does not suggest that ambulatory electrocardiography is a waste of time, but in many patients, especially those described as having transient non-focal neurological abnormalities, it is a question of balancing probabilities and frequently undertaking more than one day's monitoring.[10] In the final analysis diagnosis may rest primarily on the history rather than the results of the test.[11]

Repeated monitoring may uncover another lesson: the spontaneous variation of arrhythmias. The incidence of

ventricular extrasystoles may vary by fivefold or sixfold in two 24 hour electrocardiograms. One important implication of this variability is that an antiarrhythmic drug may only be said to be effective if the number of extrasystoles is reduced by about 80% in 24 hours.

Sudden death

Several people have died while undergoing ambulatory electrocardiography. Most were suffering from ischaemic heart disease and, as we already knew from resuscitation attempts in similar patients, most collapsed with ventricular fibrillation. The electrocardiogram rarely showed signs of acute infarction and thus corroborated the pathological and other evidence that suggests that sudden death is due to a primary electrical disturbance. Ventricular fibrillation is usually preceded by ventricular tachycardia, and this is often heralded by increasingly frequent and complex ventricular extrasystoles.[12 13] The trigger factor may be an early coupled beat.[14 15] These antecedent arrhythmias differ from those observed in asymptomatic patients with ischaemic heart disease. The ventricular tachycardia is faster and lasts longer, and the pattern of extrasystoles suggests considerable electrical instability in the hours before death, which in the reported cases tended to occur in the afternoon and evening.

One alarming feature of these deaths is their association with treatment with antiarrhythmic drugs—particularly digoxin and quinidine.[12 16] The association may not be necessarily causal, however, for sinister arrhythmias tend to occur in patients with severely damaged ventricles, who are already at risk. Nevertheless, it does suggest that it is unwise to prescribe antiarrhythmic drugs for patients with poor left ventricular function, especially if the arrhythmia is not causing symptoms.

Asystole is obviously the ultimate arrhythmia but a progressive bradycardia is less common than ventricular fibrillation. This may be because most ambulatory electrocardiographic studies of patients who have collapsed have been in those with ischaemic heart disease and abnormal ventricular rhythms. Bradycardia may precede asystole when the cause of death is non-cardiac, as in the one reported case of sudden death during ambulatory electrocardiography when necropsy showed pulmonary embolism.[17]

Occult ischaemia

Modern ambulatory electrocardiographic recorders can faithfully reproduce not only the QRS complex but also the low frequency components of the electrocardiogram such as the ST segment. Shift of the ST segment often but not invariably indicates cardiac ischaemia. Episodes of raising of the ST segment have been recorded during "normal" nocturnal bradycardia in younger men and are unlikely to be of pathological importance.[18 19] Intermittent ST segment depression is different: its frequency, magnitude, and duration are greater in patients with severe coronary disease[20]; it correlates well with reduced myocardial perfusion and with ST segment depression induced by exercise testing[20 21]; it is reduced by antianginal medication[22]; in unstable angina it predicts prognosis; and it is abolished by coronary artery bypass surgery.[23] Finally, it is rare in normal people, although there is some disagreement on this point.[18 20 24]

What does emerge is that many patients with ischaemic heart disease and angina have ST segment depression in their ambulatory electrocardiogram not only during episodes of pain but at other times as well. This discovery provokes a number of questions. Do the painless episodes represent ischaemia of small segments of myocardium[25] or an increase in the patient's threshold to pain?[26] And do they matter, given that myocardial infarction is silent in over a quarter of cases[27] and that the outlook in these patients is as bad as in those who are symptomatic? Should treatment of patients with angina aim at abolishing all ischaemic episodes or just relieve symptoms?[28] These questions are fundamental but more work is needed before they may be answered.

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1 Roberts WC, Silver MA. Norman Jefferies Holter and ambulatory ECG monitoring. *Am J Cardiol* 1983;**52**:903-6.
2 Clarke JM, Shelton JR, Hamer J, Taylor S, Venning GR. The rhythm of the normal human heart. *Lancet* 1976;ii:508-12.
3 Cats VM, Durrer D. Prevalence of cardiac arrhythmias in the normal active population. In: Roelandt J, Kugenholtz PG, eds. *Long term ambulatory electrocardiography*. The Hague: Nijhoff, 1982:123-32.
4 Brodsky M, Wu D, Denes P, Kanakis C, Rosen KM. Arrhythmias documented by 24 hour continuous electrocardiographic monitoring in 50 male medical students without apparent heart disease. *Am J Cardiol* 1977;**39**:390-5.
5 Southall DP, Johnston F, Shinebourne EA, Johnston PGB. 24 hour electrocardiographic study of heart rate and rhythm patterns in population of healthy children. *Br Heart J* 1981;**45**: 281-91.
6 Bjerregaard P. Mean 24 hour heart rate, minimal heart rate and pauses in healthy subjects 40-79 years of age. *Eur Heart J* 1983;**4**:44-51.
7 Kennedy HL, Pescarmona JE, Bouchard RJ, Goldberg RJ. Coronary artery status of apparently healthy subjects with frequent and complex ventricular ectopy. *Ann Intern Med* 1980;**92**:179-85.
8 Kennedy HL, Whitlock JA, Sprague MK, Kennedy LJ, Buckingham TA, Goldberg RJ. Long term follow up of asymptomatic healthy subjects with frequent and complex ventricular ectopy. *N Engl J Med* 1985;**312**:193-7.
9 Burckhardt D, Laetold BE, Jost MV, Hoffman A. Holter monitoring in the evaluation of palpitations, dizziness and syncope. In: Roelandt J, Kugenholz PG, eds. *Long term ambulatory electrocardiography*. The Hague: Nijhoff, 1982:29-39.
10 De Bono DP, Warlow CP, Hyman NM. Cardiac rhythm abnormalities in patients presenting with transient non-focal neurological symptoms: a diagnostic grey area? *Br Med J* 1982;**284**:1437-9.
11 Hampton JR, Harrison MJG, Mitchell JRA, Prichard JS, Seymour C. Relative contributions of history taking, physical examination, and laboratory investigation to diagnosis and management of medical outpatients. *Br Med J* 1974;ii:486-9.
12 Pratt CM, Francis MJ, Luck JC, Wyndham CR, Miller RR, Quinones MA. Analysis of ambulatory electrocardiograms in 15 patients during spontaneous ventricular fibrillation with special reference to preceding arrhythmic events. *Journal of the American College of Cardiology* 1983;2:789-97.
13 Panides IP, Morganroth J. Sudden death in hospitalised patients: cardiac rhythm disturbances detected by ambulatory electrocardiographic monitoring. *Journal of the American College of Cardiology* 1983;2:798-805.
14 Lahiri A, Balasubramanian V, Raftery EB. Sudden death during ambulatory monitoring. *Br Med J* 1979;i:1676-8.
15 Nikolog G, Bishop RL, Singh JB. Sudden death recorded during Holter monitoring. *Circulation*. 1982;**66**:218-23.
16 Denes P, Gabster A, Kuang SK. Clinical, electrocardiographic and follow up observations in patients having ventricular fibrillation during Holter monitoring. Role of quinidine therapy. *Am J Cardiol* 1981;**48**:9-16.
17 Kereiakes DJ, Morady F, Heath D, Parsons T, Scheinman MM. Sudden death during ambulatory electrocardiographic monitoring: importance of morphologic confirmation to establish cause of death. *Am J Cardiol* 1984;**53**:1403-4.
18 Deanfield JE, Ribiero P, Oakley K, Krikler S, Selwyn AP. Analysis of ST-segment changes in normal subjects: implications for ambulatory monitoring in angina pectoris. *Am J Cardiol* 1984;**54**:1321-5.
19 Quyyumi AA, Wright G, Fox K. Ambulatory electrocardiographic ST segment changes in healthy volunteers. *Br Heart J* 1983;**50**:460-4.
20 Quyyumi AA, Mockus L, Wright C, Fox KM. Morphology of ambulatory ST segment changes in patients with varying severity of coronary artery disease. *Br Heart J* 1985;**53**:186-92.
21 Deanfield JE, Shea M, Ribiero P, *et al*. Transient ST-segment depression as a marker of myocardial ischemia during daily life. *Am J Cardiol* 1984;**54**:1195-200.
22 Schang SJ, Pepine CH. Transient asymptomatic ST segment depression during daily activity. *Am J Cardiol* 1977;**39**:396-402.
23 Nudermanee K, Intarachot V, Piontek M, *et al*. Silent myocardial ischaemia on Holter: has it clinical or prognostic significance? *Circulation* 1984;**70**:45.
24 Armstrong WF, Jordon JW, Morris SN, McHenry PL. Prevalence and magnitude of ST-segment and T wave abnormalities in normal men during continuous ambulatory electrocardiography. *Am J Cardiol* 1982;**49**:1638-42.
25 Chierchia S, Lazzari M, Freedman B, Brucelli C, Maseri A. Impairment of myocardial perfusion and function during painless myocardial ischemia. *Journal of the American College of Cardiology* 1983;**1**:924-30.
26 Droste C, Roskamm H. Experimental pain measurement in patients with asymptomatic myocardial ischemia. *Journal of the American College of Cardiology* 1983;**1**:940-5.
27 Kannel WB, Abbott RD. Incidence and prognosis of unrecognised myocardial infarction. *N Engl J Med* 1984;**311**:1144-7.
28 Cohn PF. Time for a new approach to management of patients with both symptomatic and asymptomatic episodes of myocardial ischemia. *Am J Cardiol* 1984;**54**:1358-9.