Significance of abnormalities of electrocardiogram in old people

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The significance of abnormalities of the electrocardiogram in old age has been assessed from a study of 2254 people aged 65 and over living at home, by an analysis of the frequency of exertional chest pain and of histories of cardiac infarction, of mortality over a 3-year period, of certified causes of death, and of abnormalities in the electrocardiogram seen in second records made in one-third of the subjects after an average time of 21 months.

By comparison with subjects with no codable electrocardiographic abnormality, subjects with Q/QS patterns, ST-T patterns, including T wave flattening, and 'probable' left ventricular hypertrophy patterns have an increased frequency of exertional chest pain, and an increased mortality. The frequency with which death is certified as due to cardiac causes is also greater. By contrast, subjects with left axis deviation or positional changes ('minor abnormality'), with 'possible' left ventricular hypertrophy, or with left anterior hemiblock alone, do not have an increased mortality.

Study of serial electrocardiograms suggests that the voltage changes of left ventricular hypertrophy may disappear, and that ST-T patterns may change to Q/QS or left ventricular hypertrophy patterns.

The significance of these findings for the interpretation of electrocardiographic changes in the elderly is discussed.

There is a strong temptation to argue that at least minor changes in the electrocardiogram in old people should not be considered to be manifestations of disease, but rather aspects of ageing, and in consequence of little real importance. There is little factual evidence to confirm or refute this view, though Fox (1949) concluded that an abnormal electrocardiogram may adversely affect prognosis for life in old age. The present investigation continues the study of the electrocardiograms of over 2000 relatively healthy old people living at home (Campbell, Caird, and Jackson, 1974), and represents an attempt to assess the significance of various electrocardiographic changes in the elderly, from a determination of the associated symptoms, mortality, and likelihood of serial electrocardiographic change.

Methods

The methods of collection of data, and of electrocardiographic recording, coding, and classification have been described (Campbell *et al.*, 1974). Data on the presence

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or absence of exertional chest pain, and of a definite history of cardiac infarction were taken from the structured questionnaire completed for each participant.

Mortality rates were determined as follows: the date and certified cause of death were ascertained for each person known to have died between October 1970 and October 1973, by examination of copies of the death certificates sent to the Medical Officer of Health to the Burgh of East Kilbride by the registrar, for each person whose address was given as East Kilbride, whatever the place of death.

The mortality in 3 years of subjects with no codable abnormality on the electrocardiogram was determined by a life table method (Merrell and Shulman, 1955), for men and women over and under the age of 75 (Table 2). A 3-year mortality rate was similarly calculated for each subgroup of subjects with an electrocardiographic abnormality, and from this rate and the number of subjects in the group an estimate was made of the number of deaths occurring by the end of 3 years. The number of deaths expected in 3 years in each subgroup was calculated from its age and sex structure and the 3-year mortality rates of subjects with no codable electrocardiographic abnormality. The ratio of deaths estimated to deaths expected was then determined.

TABLE 1 Frequency of exertional chest pain and history of cardiac infarction in relation to electrocardiographic patterns

Electrocardiographic pattern	Total No.	Exertional chest pain		History of cardiac infarction	
		No.	%	No.	%
No codable abnormality	910	102	11	7	0.8
Minor abnormality	493	49	10	2	0.4
Q/QS ₁ pattern*	42	11	26	14	33
Q/QS ₂ pattern*	64	13	20	7	11
Q/QS ₃ pattern*	36	10	28	8	22
Possible left ventricular hypertrophy alone	77	9	12	4	5
Probable left ventricular hypertrophy alone	81	12	15	3	4
Major ST-T pattern alone	93	20	22	4	4
Minor ST-T pattern alone	154	31	20	6	4
Conduction defects*†	107	24	24	10	9

* Including subjects with other abnormalities.

† Left or right bundle-branch block, or left anterior hemiblock.

Approximately 30 per cent of the participants have accepted recall for a second (and in a small number a third) examination and electrocardiogram, after an interval averaging 21 ($\pm$ SD 5) months from the first. In those with a third electrocardiogram the second was ignored, and the final electrocardiogram coded and classified in the same manner as the initial record.

Results

Of the 910 subjects without a codable electrocardiographic abnormality, 102 had exertional chest pain (11%), and 7 (0.8%) gave a history of cardiac infarction (Table 1). The figures for the 493 subjects with minor abnormalities were similar.

By contrast, 24 per cent of those with Q/QS patterns had exertional chest pain, and 20 per cent gave a history of cardiac infarction, the proportions varying somewhat with the type of Q/QS pattern. A similar proportion (20 to 22%) of those with ST-T

patterns alone had exertional chest pain, but only 4 per cent gave a history of cardiac infarction. These percentages were virtually identical for subjects with major and with minor ST-T patterns. The proportion of subjects with left ventricular hypertrophy patterns, whether 'possible' or 'probable', with a history of cardiac infarction was similarly 4 to 5 per cent, but the frequency of exertional chest pain was less (12 to 15%). 24 per cent of subjects with important conduction defects (left and right bundle-branch block, and left anterior hemiblock) had exertional chest pain, and 9 per cent gave a history of cardiac infarction.

The 3-year mortality rates of subjects without codable electrocardiographic abnormality varied greatly with age and sex. Thus the mortality of men aged 65 to 74 was 14.8 per cent, and of women 3.0 per cent (Table 2). Comparable figures for men over 75 were 20.3 per cent, and for women 19.5 per cent

TABLE 2 Mortality of subjects without significant electrocardiographic abnormality

Electrocardiographic pattern	Sex	Age	No. of subjects	No. of deaths	Estimated 3-year mortality* (%)
No codable abnormality	M	65-74	293	25	14.8
		75+	36	4	20.3
	F	65-74	518	7	3.0
		75+	83	7	19.5
Minor abnormality	M	65-74	152	13	17.1
		75+	25	0	0
	F	65-74	255	12	7.0
		75+	57	4	9.3

* As calculated by life-table method.

TABLE 3 Mortality of subjects with significant electrocardiographic abnormality

Electrocardiographic pattern	No of subjects	Actual	Deaths Estimated*	Expected†	Ratio Estimated/Expected
Q/QS1 patterns‡	42	5	8.1	5.0	1.6
Q/QS2 patterns‡	64	8	18.8	9.0	2.1
Q/QS3 patterns‡	36	3	4.4	3.2	1.4
All Q/QS patterns‡	142	16	31.3	17.2	1.8
Possible left ventricular hypertrophy patterns§	79	1	1.2	6.2	0.2
Probable left ventricular hypertrophy patterns§	82	11	20.2	5.4	3.7
Major ST-T patterns§	93	7	10.6	7.5	1.4
Minor ST-T patterns§	154	12	28.5	12.7	2.2
Left bundle-branch block‡	31	6	7.7	2.8	2.7
Right bundle-branch block‡	40	7	9.4	4.5	2.1
Left anterior hemiblock alone‡	36	1	1.2	4.1	0.3
Incomplete right bundle-branch block‡	32	2	2.8	4.3	0.8

* 3-year mortality by life table method.

† From age and sex.

‡ Including subjects with other codes.

§ Excluding subjects with other codes.

cent. The rates for subjects with minor electrocardiographic abnormalities were very similar to those of subjects without codable abnormality.

The mortality of subjects with various electrocardiographic abnormalities is shown in Table 3. The ratios of estimated to expected deaths were less than 1 for subjects with 'possible' left ventricular hypertrophy, left anterior hemiblock alone, and incomplete right bundle-branch block. They were greater than 1 for those with Q/QS patterns of all types (1.8 on average) 'probable' left ventricular hypertrophy (3.7), ST-T patterns (1.4 for major and

2.2 for minor ST-T patterns), left bundle-branch block (2.7), and right bundle-branch block (2.1).

Of deaths of subjects without codable electrocardiographic abnormality, 28 per cent were certified as caused by cardiac disease (including sudden deaths, cor pulmonale, and deaths certified as caused by cardiac failure), 30 per cent to malignant disease, and 42 per cent to all other causes (Table 4). The pattern in subjects with minor electrocardiographic abnormality was very similar, but in those with significant electrocardiographic abnormality twice as many deaths were certified as due to cardiac

TABLE 4 Certified causes of death in relation to electrocardiographic pattern

Electrocardiographic pattern	Total no. of deaths	Heart disease		Malignant disease		All other causes	
		No.	%	No.	%	No.	%
No codable abnormality	43	12	28	13	30	18	42
Minor abnormality	29	9	31	12	41	8	28
No significant abnormality	72	21	29	25	35	26	46
Q/QS patterns	16	11	70	1	6	4	25
Left ventricular hypertrophy patterns	12	6	50	1	9	5	41
ST-T patterns	19	8	42	6	32	5	26
Conduction defects*	14	10	71	1	7	3	21
Arrhythmias†	9	5	55	2	22	2	22
Total abnormal patterns	70	40	56	11	16	19	27

* Left bundle-branch block, right bundle-branch block, and left anterior hemiblock without other abnormality.

† Atrial fibrillation or frequent ectopic beats, without other abnormality.

TABLE 5 *Change in electrocardiogram in subjects without significant abnormality*

Initial electrocardiogram	Total no.	Final electrocardiogram (%)		No significant abnormality	Significant abnormality
		No codable abnormality	Minor abnormality		
No codable abnormality	264	69	18	86	14
Minor abnormality	183	15	74*	89	11
No significant abnormality	447			87	13

* The same abnormality in 70 per cent, another minor abnormality in 4 per cent.

causes (56% overall), and only 16 per cent to malignant disease. The number of deaths in each subgroup of electrocardiographic abnormality was small, but the pattern in each group was very similar.

264 pairs of electrocardiograms were recorded in subjects with no codable abnormality on the initial trace, and 183 in subjects with minor abnormality (Table 5). Approximately 70 per cent retained their initial classification, while 15 to 18 per cent changed from no codable abnormality to minor abnormality or vice versa. More significant abnormality developed in 11 to 14 per cent. Of 125 subjects whose initial electrocardiogram showed only clockwise or counterclockwise rotation, the final electrocardio-

gram showed the transition zone in the same lead or interval between leads in 58 per cent, and in the adjacent lead or interval between leads in 90 per cent (Table 6).

Table 7 summarizes the changes in electrocardiographic patterns in subjects with significant electrocardiographic abnormality. In 43 subjects with Q/QS patterns, the Q/QS pattern disappeared in 19 per cent, leaving a record without significant abnormality in 5 per cent and an ST-T pattern in 14 per cent; 9 per cent developed left ventricular hypertrophy pattern. Of 64 subjects with patterns of left ventricular hypertrophy, the voltage changes disappeared in 28 per cent, 'possible' left ventricular hypertrophy patterns mostly changing to a pattern of 'no significant abnormality', and 'probable' left ventricular hypertrophy patterns to an ST-T pattern. When voltage changes disappeared, the initial electrocardiogram usually just satisfied the voltage criteria, and the final one just failed to satisfy them. 73 per cent of ST-T patterns (in 83 subjects) remained unchanged, and 16 per cent changed to no significant abnormality, while Q/QS patterns developed in 5 per cent and left ventricular hypertrophy patterns in 11 per cent. When ST-T patterns disappeared, flat T waves (in leads aVL or V5-6) had usually become positive, though remaining of small amplitude. The frequency of changes in other patterns could not be determined with any accuracy because of small numbers. Left

TABLE 6 *Change in position of transition zone in subjects where clockwise or counterclockwise rotation was the only abnormality*

Initial electrocardiogram	No.	Final electrocardiogram (%)	
		In same lead	Within half lead
Counterclockwise rotation	82	70	89
Clockwise rotation	43	51	91
Total	125	58	90

TABLE 7 *Changes in electrocardiographic pattern*

Initial electrocardiogram	Total no.	Final electrocardiogram (%)			
		No significant abnormality	Q/QS patterns	Left ventricular hypertrophy patterns	ST-T patterns
No significant abnormality	447	87	2	2	2
Q/QS patterns	43	5	69	9	14
Left ventricular hypertrophy patterns	64	13	0	68	15
ST-T patterns	83	16	5	11	73

bundle-branch block remained unaltered in all of 10 subjects; it appeared in 2, both with initial left ventricular hypertrophy patterns. No subject developed right bundle-branch block; it disappeared in 1 out of 11. Three subjects developed atrial fibrillation; 2 were initially among the 447 with no significant electrocardiographic abnormality, and 1 among the 45 with 'probable' left ventricular hypertrophy.

Discussion

The present study is in essence a comparison between old people with no codable electrocardiographic abnormality and those with a variety of definable changes, both groups being studied by identical methods. This fact renders less important the limitations of the sample, which have been discussed (Campbell *et al.*, 1974). It is unlikely that a subject's electrocardiographic pattern would be associated with bias in his answers to a questionnaire, the manner in which these answers were recorded, or the likelihood that he would change his residence, or refuse recall for a second examination.

The questions asked in the present study on exertional chest pain did not correspond exactly to those of Rose and Blackburn (1968), so that the term 'exertional chest pain' has been used rather than the specific 'angina'. The term 'history of cardiac infarction', undoubtedly includes only more definite instances, usually requiring admission to hospital, than Rose's 'possible infarction'.

The method of ascertainment of death used in the present study is incomplete, since the deaths of those subjects who move from East Kilbride or do not have an address in the town recorded on their death certificates will not be reported, and so will be overlooked. However, the number known to have moved in the three years covered by the study is small, and it is a reasonable assumption that deaths not ascertained for this reason would be expected to be equally distributed in all electrocardiographic groups. It is perhaps possible that some bias may have been introduced into the certification of the cause of death, if the certifying doctor knew (as was by no means always the case) of the existence of an abnormal electrocardiogram in the past.

'Minor abnormality' of the electrocardiogram includes left axis deviation without evidence of left anterior hemiblock, clockwise and counterclockwise rotation, and sinus tachycardia and bradycardia (Campbell *et al.*, 1974). The positional changes are clearly not due to faulty lead placement, since as Table 6 shows they are exactly repeatable in 58 per cent of cases, and repeatable to within one interval between leads in 90 per cent. They must, therefore, be considered as definite electrocardio-

graphic findings. However, since subjects with 'minor abnormality' resemble those with no codable abnormality very closely, in respect of their frequency of exertional chest pain and of histories of cardiac infarction (Table 1), their mortality (Table 2), and the pattern of their certified causes of death (Table 4), there is no reason to believe that any of these changes is of itself of prognostic significance in the electrocardiogram of an old person.

By contrast, Q/QS patterns are associated with a frequency of exertional chest pain two-and-a-half times greater than 'no codable abnormality', and many more histories of cardiac infarction (Table 1). The mortality of subjects with Q/QS patterns is 1.8 times that expected (Table 3), a figure of the same order as found by Higgins, Kannel, and Dawber (1965) among people aged 30 to 62 (Table 8). The certified cause of death is cardiac in 70 per cent (Table 4), over twice that of subjects without significant electrocardiographic abnormality. There is less certainty in the significance of the subdivision of Q/QS pattern into the three groups suggested by the Minnesota Code, and here called Q/QS1, 2, and 3. A Q wave duration of 0.03 sec or more is reliably associated with the presence *post mortem* of a cardiac infarct (Horan, Flowers, and Johnson, 1971), but such Q waves lead to classification into all three subgroups. Kurihara *et al.* (1967) found that electrocardiograms with a Q/QS1 pattern were more often associated with necropsy evidence of cardiac infarction in old people than Q/QS2 or 3 patterns. It is thus somewhat surprising that in the present study the frequency of symptoms and the excess mortality differs little between the three subgroups, though the data of Higgins *et al.* (1965) do not suggest any major difference in mortality in younger people.

ST-T patterns are almost as often associated with exertional chest pain as Q/QS patterns (Table 1), though the frequency of histories of cardiac in-

TABLE 8 Ratios of observed to expected deaths for various electrocardiographic patterns

	Higgins <i>et al.</i> (1965)*	This study
Age (yr)	30-62	65+
Q/QS patterns	2.1	1.8
Major ST-T patterns	3.7	1.4
Minor ST-T patterns	2.0	2.2

* Recalculated to give groups with electrocardiographic patterns comparable to those in present study; ratios are for excess risk of death from all causes relative to all subjects.

farction is only one-tenth as great. The excess mortality is of the same order as for Q/QS patterns, and the proportion of deaths certified as caused by cardiac disease little different. These statements apply as much to minor ST-T patterns as to major patterns. In younger people, Higgins *et al.* (1965) found the mortality associated with major patterns to be greater than that of minor patterns; minor patterns have, however, a mortality little lower than Q/QS patterns (Table 8). Though the serial electrocardiograms in the present study frequently show the disappearance of ST-T patterns (Table 7), in the case of T wave flattening this is often for reasons of definition. Short (1972) suggests that low amplitude T waves, which would not be coded in this or most other studies employing the Minnesota code, are in fact abnormal, because almost always associated with evidence of heart disease. Table 7 shows that Q/QS and left ventricular hypertrophy patterns develop out of ST-T patterns more frequently than out of patterns with no codable abnormality, and it may be here that the significance of ST-T patterns in old people lies, as evidence of cardiac ischaemia or early left ventricular hypertrophy. However that may be, the present study clearly indicates that in the elderly even minor ST-T changes cannot be ignored, or regarded as normal or due to age alone, but must be considered as significant abnormalities.

Kannel *et al.* (1970) suggested the division of left ventricular hypertrophy patterns into those with voltage changes alone ('possible' left ventricular hypertrophy) and those with both voltage and ST-T changes ('definite' or 'probable' left ventricular hypertrophy). Romhilt *et al.* (1969) showed that all published voltage criteria lack both sensitivity and specificity in the diagnosis of left ventricular hypertrophy. The present study supports the view that voltage criteria alone are of relatively little significance in the elderly. Thus, though subjects with 'possible' and 'probable' left ventricular hypertrophy resemble each other in the frequency of exertional chest pain and of histories of cardiac infarction (Table 1), the mortality of the latter group, but not the former, is considerably above that expected (Table 4). This is entirely in keeping with the findings of Kannel *et al.* (1970) in younger subjects. Further evidence is provided by the frequency with which voltage criteria for left ventricular hypertrophy are met by one electrocardiogram and not by another in the same subject, so that 'possible' left ventricular hypertrophy patterns revert to 'no codable abnormality', and 'probable' patterns change to ST-T patterns (Table 7). The reliability of determination of the voltage criteria employed in the Minnesota code is not in any case very high

(Elgrishi, Ducimetiere, and Richard, 1970). Kennedy and Caird (1972) suggested that the distinction between the two types of pattern might be significant in the elderly, and the validity of this suggestion has been confirmed. The significance of 'possible' left ventricular hypertrophy patterns remains uncertain.

The number of subjects with individual conduction defects is not large, but it seems that complete left and right bundle-branch block both carry an excess mortality, but that left anterior hemiblock and incomplete right bundle-branch block do not (Table 3). A great excess of sudden deaths among people with complete left or right bundle-branch block was indicated by Chiang *et al.* (1970) in a community study, and incomplete right bundle-branch block is commonly thought not to be associated with heart disease. It is unexpected to find that left anterior hemiblock may be of little significance in an old person, since this abnormality is stated to be most frequently caused by coronary heart disease (Rosenbaum, Elizari, and Lazzari, 1970). Further study of a larger group of old people over a longer period is needed to clarify this point.

In conclusion, the present investigation demonstrates the value of application of the Minnesota code to the electrocardiogram in the elderly (Kennedy and Caird, 1972), and the validity of most of the distinctions it makes possible is also clear. It supports the view that the majority of common electrocardiographic abnormalities, apart from left axis deviation and pure positional changes, and the voltage changes of left ventricular hypertrophy, must be regarded as significant when encountered in an old person. This applies to Q/QS patterns of all types, and to T wave flattening as well as inversion. These changes, however frequent they may be, cannot be disregarded and taken merely as a reflection of ageing.

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