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Value of electrocardiogram in population surveys

An attempt to improve interpretation

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The poor agreement between the questionnaire method of determining the incidence of ischaemic pain in a given population and the incidence of ischaemic electrocardiographic abnormalities has been examined by using two methods of classifying the abnormalities on the electrocardiogram: the Minnesota code and frontal plane vectorial analysis. The vectorial analysis appeared to overestimate ischaemic changes, but even so this method showed no greater agreement with the questionnaire results than the Minnesota code. This suggests that the Minnesota code is the better system, but does not explain the poor agreement with the questionnaire findings.

Field surveys have examined the prevalence of cardiovascular disease in adult populations (Epstein *et al.*, 1965; Holland *et al.*, 1967; Keys *et al.*, 1963; Reid *et al.*, 1966); all have used standardized questionnaires (Rose, 1962, 1965) and electrocardiograms (Blackburn *et al.*, 1960; Higgins, Kannel, and Dawber, 1965) as indicators of ischaemic heart disease. The results suggest that about one-third of adults with a history of chest pain suggestive of angina or myocardial infarction have significant electrocardiographic abnormalities.

In a four-year study of one population group, Rose (1968) compared point-prevalence with period-prevalence estimates, showing that point-prevalence studies may grossly underestimate the seriousness of the disease. He also showed that, in individuals, there was no obvious coincidence in time between the appearance of symptoms and electrocardiographic abnormalities. In a comparison of replies to four questionnaires and results of two electrocardiograms, he found that 19 per cent of subjects who did not complain of anginal symptoms were electrocardiogram positive on one occasion, and about 5 per cent were positive on both occasions. Ninety-two per cent who reported anginal symptoms three or four times were electrocardiogram positive on one occasion and 42 per cent were positive on both occasions. The questionnaire appears, *a priori*, to be an accurate method of detecting ischaemic heart disease, since specific symptoms are sought and doubtful chest pain is rejected as unlikely to be significant. If this is so, the electrocardiogram must be regarded as a poor indicator of the disease. It is possible that this inaccuracy might be explained by the method of interpretation used, and, in an attempt to explore this possibility further, we have applied two contrasting methods of electrocardiogram analysis to the same tracings. The two sets of results were then compared with each other and with replies to a standard questionnaire for chest pain.

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Material and methods

The subjects consisted of 775 subjects aged 35–74 years involved in a community survey of the prevalence of cardiovascular disease. The original survey group was composed of a random sample of residents of the London Borough of Lambeth stratified by age, sex, and social class. A screening questionnaire was mailed to all subjects (2,998) and a second sample, weighted towards those reporting respiratory and anginal symptoms, was then drawn.

A six-lead electrocardiogram was taken on each subject. Recordings were made on a three-channel direct-writing Mingograph recorder (Sierex Ltd.) while the subject was in a sitting position. Praecordial unipolar leads were not used as they have

been shown to add little to the diagnostic accuracy of a six-lead recording (Makous, 1965). A second questionnaire was also administered (Medical Research Council, 1966). On the basis of questionnaire replies the subjects were divided into two groups: those who reported symptoms suggestive of myocardial infarction or angina (Q-positive) and those who did not (Q-negative). Complete data were collected on 663 subjects.

Electrocardiograms were classified according to the Minnesota code (Blackburn *et al.*, 1960); after a three-month interval a second classification was given by the same subject. Where there was disagreement in coding, the tracings were re-examined and a final classification was given. A second subject, working independently, then plotted the directions of the initial (QRS_1) and terminal (QRS_T) 0·04 sec QRS vectors, the mean QRS (QRS_m) vector, and the mean T wave (T_m) vector, on a coaxial diagram (Grant, 1957). He then calculated the following angles:

1 QRS_m–T_m
2 QRS_1–QRS_T.

In addition, an ST vector was plotted, if one were present, and a note taken of all subjects with such a vector. The subjects were then divided into 4 groups:

1 Subjects with a Minnesota coding likely to indicate myocardial ischaemia (I, IV, and V items).
2 Subjects with a Minnesota coding other than the above.
3 Subjects with a vector analysis likely to indicate myocardial ischaemia (QRS_m–$T_m > 45°$; QRS_1–$QRS_T > 90°$; ST vector).
4 Subjects with a vector analysis other than the above.

These four groups were then compared to see how much overlap existed.

Results

There was a positive response to the questionnaire (see Appendix) in 171 subjects (26% of the total group). In 192, there was an 'ischaemic' Minnesota classification (28%), but the overlap between these two groups was very small (63 or 10%). In contrast, there was an 'ischaemic' vector analysis in 350 (53%), but once again there was poor agreement with the positive questionnaire response (100 or 15%). In 120 (18%) there was a positive Minnesota coding and vector analysis, but in only 39 subjects (6%) were all three positive. These results are summarized in Fig. 1.

In 492 subjects (74%) there was a negative response to the questionnaire (see Fig. 2). A Minnesota coding other than 'ischaemic' was given in 469 subjects (71%) and the overlap between the two groups was 361 (54%). A negative vector analysis was found in 313 (47%) and an overlap with the negative questionnaire group was found in 242 (36%). In 239 subjects (36%) there was a negative

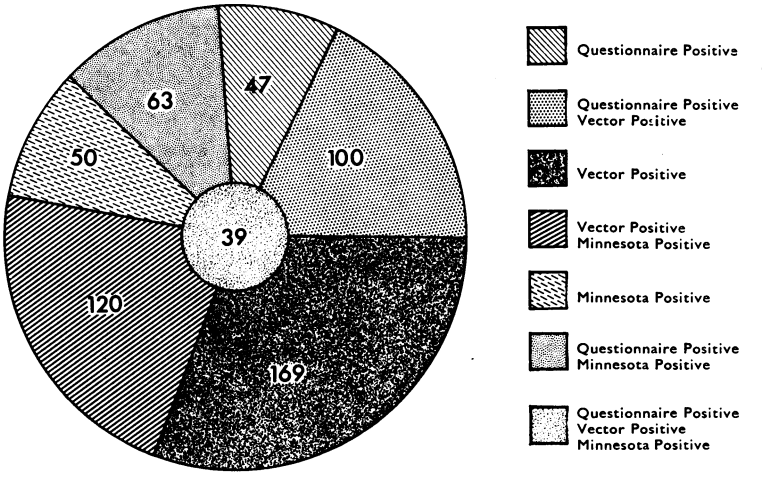


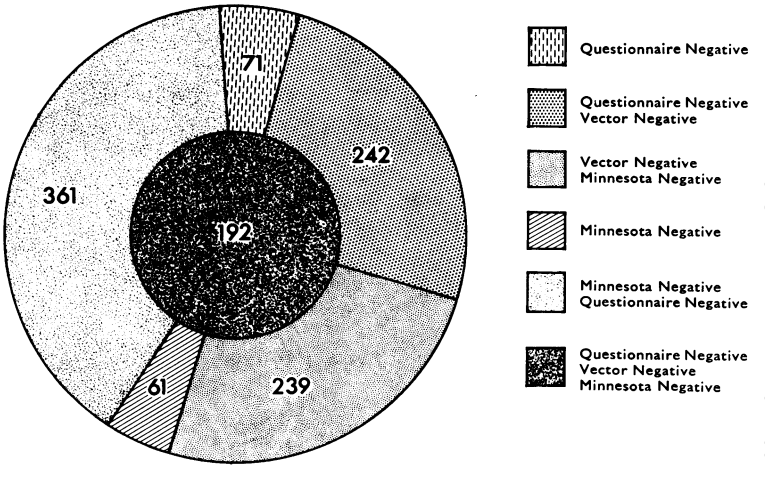
FIG. 1 *Positive correlations between the different groups.*

Minnesota coding and a negative vector analysis. In 192 (28%) there was a negative finding in all these groups.

Discussion

Studies of the prevalence and patterns of ischaemic heart disease in selected populations are complicated by the need to formulate criteria by which the presence or absence of the disease can be confidently predicted. If prospective studies are envisaged, the criteria must include an estimate of the degree of disease at the time in question. The best method at present available for demonstrating both the presence and degree of ischaemic

FIG. 2 *Negative correlations between the different groups.*



heart disease is selective coronary arteriography (Sones and Shirey, 1962), which allows direct visualization and measurement of each obstructive lesion in each artery. Recent surveys of selected patients with the symptoms of ischaemic heart disease have shown that the extent and severity of the obstructive lesions are often greater than would be expected from the traditional clinical approach of symptomatic history and electrocardiogram (Elliott and Gorlin, 1966; Gensini and Buonanno, 1968). Repeated arteriography is being used by some observers as a means of obtaining prospective information about highly-selected patients (Sones and Shirey, 1962), but this approach clearly cannot be applied to population studies. Hence the reliance which is placed upon the questionnaire and the electrocardiogram as the nearest possible approach to a full clinical examination. The combination of the two methods should give a reasonable estimate of the prevalence of ischaemic heart disease, though, as Rose (1968) has shown, the true prevalence is likely to be underestimated. It is possible that positive agreement between the electrocardiogram and the questionnaire may indicate greater severity of the disease, while a single positive finding indicates a milder degree. However, the lack of agreement between the two is a disturbing finding and greater confidence would be felt if this could be improved.

The Minnesota code is clearly a very useful method of analysing the electrocardiogram, since it reduces the interpretation to a simple numerical form which not only suggests the presence of ischaemic heart disease but gives a clear indication of the degree of abnormal change present. However, it suffers from the disadvantage that an abnormal classification may be awarded to the whole tracing if minor changes are present in one lead only. For example, a flat T wave in lead aVL would be given a positive ischaemic coding, but such a change might well be ignored by an experienced clinician in full possession of the clinical history if the results of the physical examination and the other leads of the full twelve-lead tracing were normal. The vector analysis suggested by Grant (1957) involves the determination of the direction of the mean QRS and T wave vectors in the frontal plane by direct examination of the electrocardiogram. From this, the angles between the vectors can easily be found. The normal ranges for these angles and the changes that appear when ischaemic disease is present have been determined. The advantage of this method is that all the leads are represented in the analysis, and no single lead can influence the final result unduly, and it was therefore felt that a comparison between this method and the Minnesota code would be valuable.

The results of this comparison have shown a disappointing degree of agreement between the two methods of assessing the electrocardiographic abnormalities. There was no greater agreement between the vectorial analysis and the questionnaire than between the Minnesota code and the questionnaire. In only 6 per cent of the subjects did all three methods agree upon the presence of ischaemic criteria. A much greater number of positive readings was obtained by vectorial analysis, and it seems clear that this method overestimates the ischaemic electrocardiographic abnormalities in the population under study. It is probable that the Minnesota code gives a more accurate estimate of these abnormalities. This study has, however, failed to show why there is such poor agreement between the Minnesota code and the questionnaire. The lack of agreement between the two methods of characterizing the abnormalities on the electrocardiogram suggests that the electrocardiogram may not be so useful in population studies as has been thought; it may be that it should be interpreted in each individual case only in the light of other clinical information, such as blood pressure level and questionnaire response.

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APPENDIX

Cardiovascular questionnaire

Section A: Effort Pain

(1) Have you ever had any pain or discomfort in your chest? Yes ☐ No ☐

If 'No' to question 1:

(1a) Have you ever had any pressure or heaviness in your chest? Yes ☐ No ☐

If 'No' proceed to Section B.
If 'Yes', ask next question.
If during the remainder of Section A an answer is recorded in a box marked *, proceed to Section B.

(2) Do you get it if you walk uphill or hurry? Yes ☐ No ☒
Never hurries or walks uphill ☐

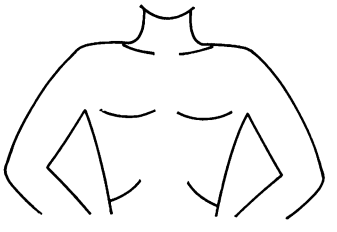
(3) Do you get it if you walk at an ordinary pace on the level? Yes ☐ No ☐

(4) What do you do if you get it when you are walking? Stop or slacken pace ☐
(Record stop or slacken pace if subject carries on after taking nitroglycerin.) Carry on ☒

(5) If you stand still, what happens to it? Relieved ☐
Not relieved ☒

(6) How soon? 10 minutes or less ☐
More than 10 minutes ☒

Will you show me where it was?
(Record all areas mentioned.)



(7) Sternum (upper or middle) ☐
(8) Sternum (lower) ☐
(9) Left anterior chest ☐
(10) Left arm ☐
(11) Other ☐

(If 'Other', mark on diagram)

(12) Do you feel it anywhere else? Yes ☐ No ☐
(If 'Yes', record additional information above.)

Section B: Possible Infarction

(13) Have you ever had a severe pain across the front of your chest lasting for half an hour or more? Yes ☐ No ☐

(14) How many of these attacks have you had?

	Date	Duration	Other Information
1st attack	.....	.....	.....
Last attack	.....	.....	.....

(15) Have you ever had an electrical recording of your heart (ECG)? Yes ☐ No ☐
If 'Yes', where? .....
when? .....

(16) Did you see a doctor because of this pain? Yes ☐ No ☐
If 'Yes', what did he say it was? .....

Cardiovascular Questionnaire Coding

		50	
Effort Pain	If 'Yes' to (7) or (8) or (9 & 10) { If 'No' to 3	☐	1
	If 'Yes' to 3	☐	2
	Otherwise	☐	3
		51	
Possible Infarction	If 'Yes' to 13	☐	1
	If 'No' to 13	☐	2