Since we know ϕ_1 ϕ_2, see (p) above, and the denominator of the fraction contains terms we know, ∴ Q is known. Thus the moment (strength) of the dipole is known. Thus leads ABC define the dipole completely.

1. *Modification owing to the fact that the emanation is not precisely that of a dipole.*—Craib (1927) has presented strong evidence that we may regard the field as being produced by a dipole, and, since in the final analysis related ionic migration through muscle membrane is associated with the action current produced, this would appear to be a sound hypothesis. Let us first assume it is a point source at the centre producing an emanation of the type f (t). The above treatment still holds, since we can select any particular instant in the cycle of f (t) which will correspond to a selected dipole as treated above.

2. *The thorax is (a) not a sphere, (b) not a perfect conductor and impedance varies throughout its volume, and (c) the heart is not a point source at the centre.*—(*a*) If points M, L, and R (ϕ_1, ϕ_2, ϕ_3) are not at equidistance from the centre and the thorax forms an ellipsoid since these variations are known, then the treatment is more complicated; but the actual conclusion—namely, that neither the strength (Q) nor the direction of the dipole (l, m, n) can be changed without producing a reflected change in lead A, B, or C—is a reasonable deduction. (*b*) This factor is difficult to evaluate. Kaufman and Johnston (1943) consider that variations of this nature, since they are not major, do not affect the recorded potentials greatly. (*c*) Though the heart is not a point source it is still theoretically possible to treat all the emanating points individually and summate algebraically, and therefore we should still obtain an equation related to the known findings appearing from leads A, B, and C. The final difficulty will arise if and when fields produced can annul one another as in precisely accurate phase difference of 180 degrees. This could not be expected to occur with infarction owing to the type of firing off of the heart muscle, and this has already been discussed.

Summary

A series of 161 cases of cardiac infarction on whom ABC electrocardiograms were performed has been presented. Necropsies were done on 36 of these subjects.

The ABC display detected all cases of infarction detected by the present standard leads, and in addition detected infarction not demonstrated by them.

The correlation of infarct site with pattern changes in the ABC leads was determined theoretically and confirmed by necropsy studies.

E.C.G. patterns indicating cardiac degeneration short of discrete infarct formation, with one necropsy study, are described.

Abnormal T-wave form associated with infarction is illustrated.

Heart-block patterns associated with infarct formation are described and presented.

A theoretical analysis of the significance of the Einthoven, Goldberger, Wilson, and ABC leads is presented.

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INCIDENCE OF CORONARY ISCHAEMIA AFTER PARTIAL GASTRECTOMY

BY

R. S. WALKER, M.D., F.R.F.P.S., M.R.C.P.Ed.
Senior Registrar, Law Hospital, Carluke

W. C. WATSON, M.B., F.R.F.P.S., M.R.C.P.
Senior Registrar, University Department of Medicine, Glasgow Royal Infirmary

AND

J. K. WATT, M.B., F.R.C.S., F.R.F.P.S.
Consultant, Eastern District Hospital, Glasgow

There are many studies relating coronary artery disease to various aspects of lipid metabolism. It has been shown that the incidence is high where the diet contains a large quantity of animal and saturated fat, and low where fat intake is poor (Keys, 1956). Following partial gastrectomy of the Polya type many patients lose weight and most are below their expected weight (Anderson *et al.*, 1955). This is probably due to a low calorie intake and post-gastrectomy symptoms, but impaired digestion and absorption of fat may be a contributory factor. Recent work in gastrectomy patients with ^{131}I labelled fats has shown increased fat excretion and diminished absorption after fatty meals and that fat loss is greater after the Polya operation than after the Billroth I (Everson, 1954; Shingleton *et al.*, 1957). This impaired fat absorption could be reflected in a lower incidence of coronary artery disease in gastrectomy patients.

Material

Of 53 patients who had undergone the Polya type of partial gastrectomy 40 were traced and examined. All were males between 45 and 65 years who had been operated on for severe duodenal ulcer symptoms. The mean lapse of time from operation to interview was 9 years 10 months (range: 7 years 1 month to 13 years 4 months). At the same time, 40 men in the same age group with long-standing symptoms of duodenal ulcer (mean duration 17 years) were studied; 15 of these patients had suffered major complications such as perforation and haemorrhage. As a further control group we examined 40 "normal" males without ulcer or cardiac symptoms admitted for operative treatment of minor surgical and orthopaedic conditions (hernia, varicose veins, haemorrhoids, etc.). In the latter two groups the last five or six patients were selected on an age basis to ensure that the mean ages of each group were closely related (Table I).

Methods

A clinical history and an examination of each patient were undertaken; height, weight, pulse rate, and blood pressure were recorded and a sample of venous blood was withdrawn for haemoglobin and lipoprotein estimations. Electrocardiography was performed, using a direct writer ("mingograph") before and after Master's (1950) double two-step test. The amount of exercise in this test is graduated according to the patient's weight and age. One man

with a previous myocardial infarction was not exercised, and in two others the exercise was discontinued because of angina; all others completed the test. To facilitate rapid recording after exercise only nine leads were used—the three standard leads and aVR, aVL, aVF, V_2, V_4, and V_6. The records were studied independently by two of us without reference to the patient's group, and the findings compared. A further independent opinion was obtained where a difference in interpretation occurred.

It is difficult to apply rigid standards to the interpretation of electrocardiograms, but the following criteria of ischaemia were adopted as a guide: ST depression of 1 mm. or more where the increase in pulse rate did not exceed 20 a minute and of 1.5 mm. or more where it did; flat or inverted T waves in appropriate leads; and multiple extrasystoles. All other abnormalities were noted and care was taken to distinguish changes due to tachycardia alone—namely a low RS-T junction with upward-sloping ST segment. The distinction between the lateral ischaemia of coronary artery disease and that of left ventricular strain is taken into account in the analysis of the results. A typical abnormal record is shown in Fig. 1. Fig. 2 shows alternate ventricular extrasystoles occurring after exercise. This, the only example of its kind, was accepted as evidence of ischaemia.

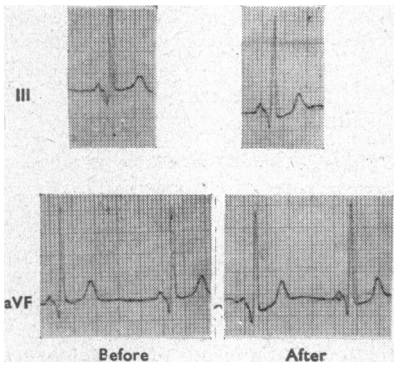

FIG. 1.—Posterior ischaemia after exercise.

The $\beta:\alpha$ lipoprotein ratio was estimated by standard methods of electrophoresis, Sudan-black staining, densitometry, and planimetry (Swahn, 1952). Pre-β lipoprotein was noted when present (Besterman, 1957).

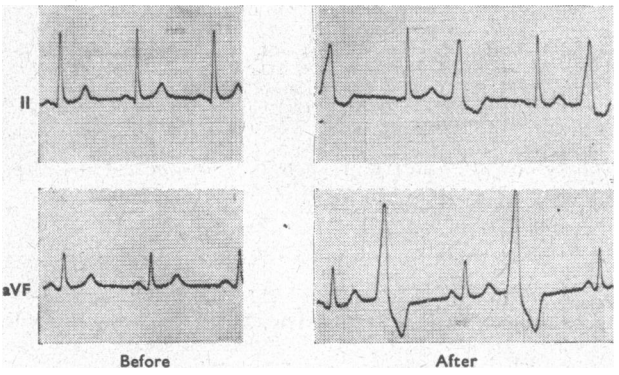

FIG. 2.—Alternate ventricular extrasystoles after exercise.

Results

A summary of the principal findings is presented in Table I, and the abnormal electrocardiograms are classified in Table II.

The incidence of myocardial ischaemia in the gastrectomy group (six positive E.C.G.s) is less than in the control group (15 positives), and this difference is significant ($\chi^2 = 5.23$; $0.02 > P > 0.01$). The difference is even more significant when the gastrectomy group is compared with the ulcer group (21 positives) ($\chi^2 = 12.6$ and $P < 0.01$). The difference between the control and ulcer groups is not significant ($\chi^2 = 2.49$). If the electrocardiograms showing left ventricular (L.V.) strain are included in the analysis (Table II) the significance of the data is altered and the difference between the control and ulcer groups becomes less marked. The number of abnormals in each group becomes gastrectomy 7, control 18, and ulcer 21, so that for gastrectomy and control groups $\chi^2 = 7.05$ ($P < 0.01$) and for the gastrectomy and ulcer groups $\chi^2 = 10.80$ ($P < 0.01$).

TABLE I.—*Summary of the Principal Findings. Each Group Contains 40 Patients*

Group	Mean Age (Yrs.)	Mean Hb %	Mean Weight lb.	Mean Weight kg.	No. of Ischaemic E.C.G.s	Mean $\beta:\alpha$ Ratio (Lipoproteins)	No. with pre-β Lipoprotein
Polya gastrectomy	53·2	88·2	132	59·9	6	2·17	16
Range..	45–65	59–103	103–183	46·7–83		1·12–4·00	
Control ..	53·6	96·7	154	69·9	15	2·42	17
Range..	46–64	77–118	114–208	51·7–94·3		1·17–4·24	
Ulcer ..	53·5	97·7	147	66·7	21	2·49	16
Range..	47–64	80–112	110–202	49·9–91·6		1·00–7·20	

TABLE II.—*Classification of the Diagnoses of the Abnormal E.C.G.s*

	Post. Ischaemia	Post.-Lat. Ischaemia	Lat. Ischaemia	Ant.-Lat. Ischaemia	Ant. Ischaemia	Infarction	Extrasyst.	Total	L.V. Strain	Misc.
Polya gastrectomy	4	1	—	—	—	—	1	6	1	1 Low voltage with emphysema
Control ..	7	7	—	—	1	—	—	15	3	1 R.V. strain
Ulcer ..	11	3	3	2	1	1 Healed post. infarct.	—	21	—	—

These figures suggest that the cardiac status of the gastrectomy patient is better than that of his fellows. Because the gastrectomy group is much lighter than the other two (Table I) and the mean weight of the six ischaemic gastrectomy patients (154 lb.; 69.9 kg.) is greater than the group mean, it seems possible that ischaemia is related to weight. However, no correlation between absolute weight and ischaemia was found in the ulcer and control groups.

Each patient's expected weight, depending on height and age, was calculated from British tables (Levine, 1923), and Fig. 3 shows the deviation from expected weight in each group, with the corresponding distribution of ischaemic E.C.G.s. This demonstrates clearly that the occurrence of myocardial ischaemia is not prevented by being underweight, and that in this series ischaemia is not related to obesity, for 16 (38%) of the 42 ischaemic E.C.G.s occurred in subjects who were more than a stone (6.4 kg.) less than their expected weight; alternatively, 16 of 53 people (30%) whose weights were at least a stone (6.4 kg.) less than their expected weight had E.C.G. evidence of ischaemia. Thus while there is a clear difference in the weights of the groups, and while

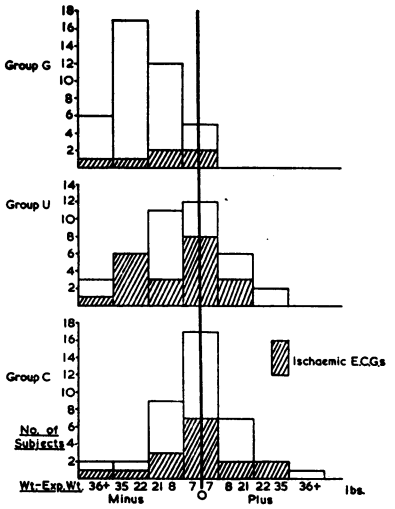

FIG. 3.—Distribution of ischaemic E.C.G.s and subjects' weights related to expected weights.

this corresponds to the incidence of myocardial ischaemia, weight by itself does not seem to be a specific factor.

There is a difference between the mean $\beta:\alpha$ lipoprotein ratios of each group (Table I). The ratio of the gastrectomy group is 89.5% of the mean control ratio and 87.0% of the mean ulcer ratio, but these differences are not significant ($P > 0.1$ in both cases). There is no difference between the mean ratios of the 42 ischaemic and 78 non-ischaemic patients, which are 2.38 and 2.35 respectively.

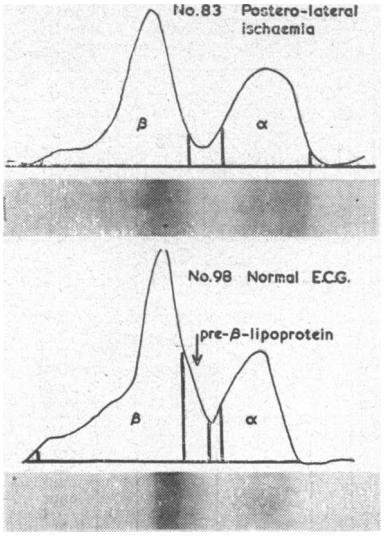

FIG. 4.—Normal lipoprotein pattern with abnormal E.C.G. (No. 83) and normal E.C.G. with pre-β lipoprotein (No. 98).

Forty-nine patients in the series had a pre-β lipoprotein band—19 (45%) of the 42 ischaemic patients and 30 (38%) of the 78 non-ischaemic patients. Fig. 4 shows the lipoprotein patterns in two people; one had ischaemia but shows no pre-β lipoprotein band, the other had no ischaemia and does.

None of the other aspects investigated showed any significant difference between the groups, apart from the low mean haemoglobin level of the gastrectomy patients (88.2%). This is actually an adverse factor which would tend to increase the number of positive electrocardiograms in this group.

Discussion

There is inevitably some selection of patients for gastrectomy. Nevertheless only one of the present ulcer group would be refused gastrectomy on a normal assessment of fitness, and all were fit 10 years ago. We consider that there is insufficient evidence of selection in favour of the gastrectomy group to invalidate the findings.

It may be argued that the incidence of abnormal electrocardiograms in this study is suspiciously high. Certainly Master *et al.* (1942) found no significant changes in the electrocardiogram following the double two-step test in 34 normal subjects of unspecified age. Against this, Riseman *et al.* (1940), employing criteria of abnormality more severe than Master's and comparable to our own, found significant changes in 10 of 15 normal patients whose ages ranged from 25 to 73 years. In a review of the literature they drew attention to the divergent findings of a number of authors. We cannot reconcile such differences. Here we are reporting results obtained from a standard test consistently applied to each of the clinical groups.

We believe that the cardiac status of the long-term gastrectomy patients is better than that of his "normal" or "ulcer" counterpart. Electrocardiographic evidence of myocardial ischaemia in the absence of anaemia is usually regarded as indicating coronary artery disease, and presumably the gastrectomy patients show less ischaemia because their coronary arteries are healthier. This suggests that in the time since operation their coronary vessels have either remained healthy and undergone minimal atheromatous change, or have even recovered from such change if initially present. In a pathological study Wilens (1947) concluded that regression of established atherosclerosis occurred in clinical states associated with severe short-term malnutrition and weight loss. This clinical study may support his view.

Weight loss by itself does not seem to be the main factor, and it is tempting to relate the lower incidence of ischaemia in gastrectomy patients to the diminished fat intake and impaired absorption which frequently occurs after a Polya gastrectomy. This, however, has not been reflected in a significantly lowered $\beta:\alpha$ lipoprotein ratio, nor can we demonstrate a relationship between pre-β lipoprotein and myocardial ischaemia. It is true, however, that by the nature of Master's double two-step test we are dealing with coronary artery disease of less severity than that recently studied by Besterman (1957, 1958), and this may explain our inability to demonstrate the lipoprotein changes which he describes.

This study confirms the opinion of Douglas and Melrose (1955) that there is no increase in the incidence of coronary artery disease in ulcer patients compared with the normal individual.

Summary

Evidence is presented which demonstrates a significantly lower incidence of coronary ischaemia in long-term gastrectomy patients compared with "ulcer" and "normal" controls.

This cannot definitely be related to lowering of the $\beta:\alpha$ lipoprotein ratio nor to changes in the pre-β lipoprotein.

Although the gastrectomy patients are much lighter as a group there is no direct relationship between weight and ischaemia.

We thank Professor C. F. W. Illingworth for access to records and for the facilities so readily granted; Miss McCann for assistance with the electrocardiography; Miss Murray for secretarial help; and Mr. Kelly for preparation of the illustrations.

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"In these days it is not uncommon to hear in some quarters debates on the relative merits of science and the arts in education. In my own University College of North Staffordshire a regard for both these two branches of learning is considered essential in every undergraduate's studies, and we have, I think, achieved a very happy marriage between them. But it was long ago that Cambridge realized that both are equally important to a true university, and it emphasized its view by creating, in 1702, the Chair of Chemistry as one of the first dozen Chairs in the University. Since that time it has continuously expanded its activities and has established a tradition in natural science which is outstanding among the universities, not of this country alone, but of the world. What other university can match the names of Newton, Darwin, Clerk Maxwell, Thomson, Rutherford, and Hopkins—to mention but a few of its famous men?—H.R.H. PRINCESS MARGARET on the occasion of the opening of the new Chemical Laboratories at Cambridge on November 6 (*Cambridge University Reporter*, November 12).