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ANGINA OF EFFORT: A CLINICAL STUDY

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The clinical differences between the types of cardiac pain have been described in a previous paper (Bourne, 1935) and have also been stressed in a later one, "Angina Innocens: A Clinical Study"* (Bourne, 1937). The present communication is a full analysis of a series of 112 patients suffering from the symptom of angina of effort. The method of presentation of these papers dealing with the various types of cardiac pain might suggest that an attempt was being made to describe individual diseases. This is by no means the case, but the definite clinical pictures provided by the different varieties of cardiac pain are so clear and distinct that it is believed that the mechanisms vary in each individual type of pain. Since at the moment it is quite impossible to determine minor and transitory changes in the coronary circulation by any other means, a careful scrutiny of the symptomatology is an essential method of approach to the problem. There are several possible organic causes of the symptom of angina of effort, presupposing this symptom to be the result of interference with coronary flow during exercise: coronary atheroma and syphilis of the aorta interfering with coronary flow are the commonest causes. Furthermore, cases have been described where severe anaemia was associated with angina of effort and where no evidence of cardiovascular disease was found at necropsy. (Cabot, 1926; Willis and Giffin, 1927; Elliott, 1934.)

The large majority of the patients here described were presumably suffering from coronary atheroma; seven had syphilitic aortitis, and one of these also had hypertension; one patient showed Addisonian anaemia as the only abnormality; and two had severe hypochromic anaemia; one of the last two, who in addition had aortic stenosis, lost his pain when the anaemia had responded to treatment.

Definition and Symptomatology

By angina of effort is meant a cardiac pain generally arising centrally or to the left of the sternum, sometimes radiating to one or both arms, which has an exactly quantitative relation to exertion. In a given case a given

amount of exertion will produce the pain, and cessation of that exertion will be followed immediately by a progressive diminution in and the disappearance of the pain. The pain never comes on at rest, except for the following exception. In a few cases, as in 10.7 per cent. of the present series, severe emotion may produce some pain; and since such emotion is associated physiologically with an increase in the heart rate and a raised blood pressure, it would be curious if in cases of angina of effort pain did not occasionally appear under these circumstances also. The effect of emotion in patients with angina of effort, however, is subsidiary in point of degree. The patient does not spontaneously complain that emotion produces the pain; it is only in response to a leading question that this is discovered. The outstanding symptom is pain which accompanies physical exertion, quantitatively, and which disappears with rest. The series here described is one consisting of cases of pure angina of effort; this fact is stressed because in any large consecutive series of cases of cardiac pain mixtures of the types of pain are not infrequent—for example, spasmodic angina is nearly always superimposed on an angina of effort, angina of effort is frequently complicated by coronary thrombosis, and the angina innocens type of pain has been observed to follow a coronary thrombosis. The various clinical pictures, however, are definite and distinct. *Provided a careful history is taken*, confusion between the different types of pain should not occur.

Reasons for Analysis

The chief reasons for analysing carefully a group of patients suffering purely from angina of effort are: first, that the different history from that given by patients with spasmodic angina suggests the presence of a different mechanism of pain production; secondly, that many patients are met with who have a history of pure angina of effort, and it is therefore helpful, so far as prognosis is concerned, to determine the expectation of life in a fairly large group of patients with an uncomplicated history of this definite symptom; thirdly, that with the introduction of new methods of treatment an accurate classification of clinical material is likely to be helpful in more accurately gauging the results of such treatment.

Exercise or physical effort produces different effects on the different types of cardiac pain. In the case of angina of effort this has already been described. An attack of

* Since the publication of the above paper a certain amount of criticism of this label has arisen. Such criticism, as in the case of "pseudo-angina" and "secondary angina," has been entirely destructive. It is clear that the syndrome needs a definite name in order to stimulate an accurate inquiry into the signs and symptoms present in any individual patient. It is therefore in the hope that some better nomenclature may arise, and in the absence of any better term, that the name "angina innocens" is maintained.

spasmodic angina is often initiated by exercise, but on the cessation of exercise a spasmodic attack continues or becomes even more severe; it "has to run its course." In the case of angina innocens (Bourne, 1937) it is often inaccurately stated by the patient that exercise brings on the pain, but further careful analysis of the symptom makes it clear that the pain is worse *after* rather than during exercise, and is continued for a long period while the patient is at rest. Coronary thrombosis occasionally manifests itself, if the thrombosis is a small one, by an angina of effort type of pain; but in contradistinction to the cases without thrombosis the onset is sudden, and after some days the pain generally becomes considerably less severe, and frequently disappears; the suddenness of the onset, the early severity, and the progressive improvement are characteristic of this latter clinical type.

Angina of effort, on logical grounds, would appear to be the type of pain most likely to be associated with a chronic organic lesion interfering with the coronary circulation. This probability seems to be borne out by the analysis of the present series of cases.

Historical

The relation between exercise and anginal pain has been recognized since the days of Heberden, and the probable relation between this type of pain and disease of the coronary vessels has been suspected since the observations of Jenner. There appears, however, to be no clinical study restricted to cases which show this pure exercise type of pain only. The historical steps subsequent to the writings of Heberden, Jenner, and Parry have been traced in Lewis's paper (Lewis, 1932), which also describes a series of experiments on the rhythmic and repeated muscular contractions in an arm whose blood supply was periodically occluded by a sphygmomanometer band. Lewis's main conclusions are that the pain produced in the muscle under these conditions is not due to the presence of arterial spasm and that it is not a direct result of lack of oxygen. He believes that the "pain is due to a stimulus arising directly or indirectly out of the contraction process," and that some chemical or physico-chemical agency is present as a causative factor within the muscle mass. Further, he concluded that this factor acts in tissue spaces though it is dependent on processes occurring within the muscle fibre as a result of its contraction. He believes that the pain is due to the accumulation of the factor in the tissue spaces, this accumulation being assisted if the blood flow through the spaces is lessened, and prevented if the blood flow is adequate. The condition in the heart whose circulation is impaired during exercise is probably closely analogous to that present in the muscles of the arm when these are exercised during a period of ischaemia.

Clinical Material

The clinical material of our series consists of 112 cases, forty-three seen in private practice and sixty-nine in the cardiac follow-up department of St. Bartholomew's Hospital. Of these, ninety-eight, or 88 per cent., were men, and fourteen, or 12 per cent., were women. In the private group there were three women, or 7 per cent., and in the hospital group eleven women, or 16 per cent. The age incidence is shown in the following table, the most striking fact perhaps being the earlier incidence of the syndrome in hospital cases. This may be explained by one of two factors—either that worry is more severe or that atheromatous changes are more common in the latter class.

TABLE I.—*Age Incidence*

Age	Private	Hospital	Total
30-39	0	4	4
40-49	4	14	18
50-59	15	22	37
60-69	17	24	41
70-79	7	5	12

Methods of Examination

In all cases a full history was taken. In the past history the following points were specifically investigated: rheumatic fever, growing pains, chorea, scarlet fever, tonsillitis, diphtheria, syphilis, and the history of the puerperium. Note was also taken of other diseases or surgical operation. A history of previous mental stress or trouble was not inquired into in every case. The following symptoms were investigated in each patient: pain, dyspnoea, sighing, orthopnoea, feeling of constriction, palpitation, exhaustion, cough, giddiness, dyspepsia, state of the bowels, catamenia, frequency of micturition. With regard to the pain the points elicited were: its character, position, radiation, duration, relation to exercise and emotion. The patients were asked whether the pain occurred during exercise, in a quantitative manner, or whether it would be worse when the exercise had been finished; also whether it was ever evident when they were resting or in bed. Inquiry was made about their present and past work, their ability to play games, to walk (with special reference to hills), to climb stairs, and to run; and also the quality of their sleep and their habits as regards smoking and alcohol.

Physical examination included special notice of the presence of dyspnoea, orthopnoea, cyanosis, pallor, pulsation, clubbing of the fingers, and tremor; the pulse rate; the state of the peripheral arteries and veins. The heart was examined by inspection, palpation of the apex beat, palpation of the praecordium for abnormal impulse or thrills; the position of the apex beat, the area of cardiac dullness, and the sounds were noted. Precordial hyperaesthesia was tested for in every case and the lungs and abdomen examined. An electrocardiogram was taken, and in some cases repeated. The Wassermann test was done. A six-foot film of the heart was taken, the contour of the heart noted, and the heart-chest ratio measured. In the private cases, however, a Wassermann reaction was only done if syphilis was definitely suspected, and an x-ray examination was not made in all cases.

Aetiology

The following were the chief points which emerged in considering the previous history of these patients. There was a history of rheumatic fever or chorea in ten, or 8.9 per cent. A history of syphilis was present in sixteen, or 14.3 per cent.; of these sixteen cases five gave a positive history of previous infection, the Wassermann reaction being negative, and seven had at the time of examination clinical evidence of a syphilitic aortitis with a positive Wassermann reaction. Syphilis and rheumatism were both somewhat commoner in the hospital group. A history of malaria was present in nine, or 8 per cent. Nine patients, or 8 per cent., had diabetes mellitus. One patient was suffering from pernicious anaemia, and two from idiopathic hypochromic anaemia; in all three cases successful treatment of the anaemia removed the cardiac pain. The state of the gall-bladder

was carefully investigated by cholecystography in all patients showing symptoms giving rise to suspicion of this condition. Cholecystitis was suspected in five patients, and was proved to be present in three cases. Among the other pathological states occurring in these patients the most striking is hemiplegia, which was found in three cases. Herpes zoster had occurred in three cases also.

An attempt was made to divide off the patients according to the physical and mental stress of their professions in order to determine the effect of this upon the presence of angina of effort. The mode of life was physically strenuous in thirty-two, or 28 per cent.; was physically and mentally strenuous in fourteen, or 12 per cent.; was mentally strenuous alone in forty-one, or 36 per cent.; or not strenuous physically or mentally in twenty, or 18 per cent. In 6 per cent. of cases there is insufficient evidence in the notes to come to an opinion on this point.

The Pain of Angina of Effort

The site of origin of the pain was worked out independently in the private group by G. B. and in the hospital group by R. B. S.; the results in each group are strikingly similar. The pain was central in 70.1 per cent. of the hospital cases and in 70 per cent. of the private cases. It arose in the left chest in 17.4 per cent. of the hospital cases and in 17.6 per cent. of the private cases. When angina of effort arises in the left chest it tends to appear in the upper rather than the lower half and does not start from the region of the heart's apex; these are minor distinctions between the left-sided pain of angina of effort and the left-sided pain of angina innocens. It started in the right chest in 4.4 per cent. of the hospital cases and in 4.7 per cent. of the private cases. The origin was epigastric in 4.4 per cent. of the hospital cases and in 2.3 per cent. of the private cases. It started in the left hypochondrium in one case, and in the left arm in two cases. Radiation was not invariable, as the pain remained localized to the site of origin in thirty-eight cases. When radiation occurred it was most frequent to the left arm; it sometimes occurred to both arms and less frequently to the right arm alone. Radiation to the abdomen and to the throat also occurred.

The association of the pain of angina of effort with other symptoms is shown in Table II. The accentuation

TABLE II.—*The Association of Angina of Effort Pain with Other Symptoms*

	Private Cases		St. Bart's		Total	%
	No.	%	No.	%		
With dyspnoea	19	44.2	54	78.3	73	65.1
On undressing	2	4.7	4	5.8	6	5.4
With constriction	23	53.5	50	72.5	73	65.1
With palpitation	0	—	11	16.0	11	9.8
With giddiness	2	4.7	3	4.4	5	4.5
With exertion after meals. (Total number)	9	21.0	26	37.7	35	31.2
With exertion after meals and without actual dyspepsia	6	14.0	11	16.0	17	14.9
Pain increased in cold wind ..	3	7.0	5	7.3	8	7.1
Patients who "walk it off" ..	5	11.7	4	5.8	9	8.0
Patients with dyspepsia. (Total number)	9	21.0	30	44.0	39	34.8
Patients with dyspepsia in whom food did not affect the anginal pain	6	14.0	14	20.3	20	17.8

of the pain if exercise is taken following a meal is clearly shown, but the effect of cold is less marked than in spasmodic angina. In some patients the severity of

the true angina of effort pain following a meal is so extreme that almost invariably in the case of the patient, and sometimes in the case of his medical attendant, it is thought to be due exclusively to some form of dyspepsia. The effect of food physiologically is to produce splanchnic congestion and systemic ischaemia, to increase the forcefulness of cardiac contraction, and to produce changes in visceral nervous tone. It is thus easy to account for the exacerbation of effort pain after food in patients suffering from angina of effort. The ability of certain patients to "walk off" the pain, or as in one case to work it off by the use of a heavy hammer, was originally noticed by Heberden, one of whose patients wrote him a letter describing accurately this peculiarity (Heberden, 1785). The fear of impending death, which is such a dramatic characteristic of the typical attack of spasmodic angina, has not been met with at all in the present series of cases of angina of effort. The explanation is probably that in this condition relief from the pain can be obtained immediately by ceasing the effort which is producing it. The patient thus does not push himself to a point where a pain is at all severe. In spasmodic angina, where the attack has to run its course, however slight the causative stimulus may have been, the patient feels helpless in the presence of the attack, which as it were gets out of hand. In these circumstances a sensation of impending death is easily understandable.

Other Cardiovascular Symptoms

Orthopnoea was present in 31 per cent. of the cases and paroxysmal dyspnoea in 4.5 per cent., but slight exhaustion was frequent, as it occurred in 52 per cent. Exhaustion of a severe type was complained of in only 5.4 per cent. Giddiness was fairly common, as would be expected in patients with vascular disease; giddiness on rising was present in 15.8 per cent., and giddiness at other times in 24 per cent. Fainting occurred in only two cases, one of these having aortic regurgitation.

Incidence of Cardiovascular Disease in Angina of Effort

Of the 112 patients, six died suddenly and unexpectedly; two died with the classical symptoms of acute left ventricular failure; twenty-eight suffered from a coronary thrombosis, proved electrocardiographically or giving a typical history; four suffered from aortic stenosis and three from aortic regurgitation; four had a proved active syphilitic aortitis; four had a systolic murmur at the aortic base, together with an enlarged heart as proved radiologically; one had a harsh systolic murmur typical of mitral regurgitation, with a systolic thrill at the apex, and with hyperpiesis; four had bundle-branch defects, shown electrocardiographically; five had inversion of the T wave in Lead I or II, or both; two had PR intervals greater than 0.2 of a second; fourteen had hyperpiesis together with enlargement of the heart, as shown radiographically; seventeen had enlargement of the heart, proved by radiograph, with a normal blood pressure; and five had hyperpiesis without evidence of cardiac enlargement. This leaves a group of thirteen, or 11.6 per cent., in whom no evidence of cardiovascular disease was discovered. It is apparent that 88.4 per cent. provided unquestionable evidence of chronic cardiovascular disease.

It must, however, be remembered that a heart may appear normal clinically, electrocardiographically, and by x-ray examination, and may yet have an advanced degree of coronary disease (Bourne, 1936). A further point to be remembered is that interference with coronary

flow may only be relative. Coronary ischaemia may occur either because there is a narrowing of some part of the coronary circulation or because there may be at some point in the coronary circulation an area of slight disease which produces loss of elasticity of the vessel. Under this latter condition the coronary flow would be normal except during such a state of exercise as would require a greater flow of blood than the inelastic vessel could provide. The cardiac nutrition would not suffer under these circumstances, but pain of a typical effort character would result from the relative cardiac ischaemia produced during exertion. The presence or the degree of pain depends also on other factors, such as possibly the psychological state of the patient (Bourne, Scott, and Wittkower, 1937; Wittkower, 1937), or on the degree of sensitiveness of the nervous system.

Three negative points are worthy of notice. In the above list of cardiovascular conditions there is no case of congestive failure, no case of auricular fibrillation, and only one of mitral disease, this being a case of mitral regurgitation. Mitral stenosis is conspicuously absent.

Relation between Angina of Effort and Coronary Thrombosis

The estimation of the incidence of coronary thrombosis in a series of cases depends, first, upon the proof of the condition electrocardiographically, and, secondly, on the presence of a typical history of an attack. We did not regard the latter point as positive unless the patient had suffered from a severe attack of precordial pain, so acute as to be incapacitating and lasting continuously or intermittently over a number of days. In many cases there was a history that the pain needed relief by an injection of morphine, and in most of them there was evidence that such an attack was followed by a diminution in the patient's powers of physical activity. Wherever an attack of this nature had been sufficiently recent the correctness of the diagnosis was confirmed by the fact that changes were still occurring in the electrocardiographic tracings.

Coronary thrombosis might initiate the patient's period of ill-health, might occur as an incident during its course, or might be the terminating event of the illness. Coronary thrombosis was proved to have initiated the condition in two cases, and a typical history suggesting that it had done so was present in fifteen others; it was proved to have occurred in two cases during the course of the illness; and a typical history of coronary thrombosis was present in ten others, also during the course of the illness. Coronary thrombosis was proved to have terminated the illness in two cases, and probably did so in one other. The total number of patients having a coronary thrombosis at some time during the illness was thirty-two, or 28.6 per cent.; the number having more than one coronary thrombosis was five, or 4.5 per cent.

The clinical history of angina of effort, in so far as this condition is related to coronary thrombosis, may be of one of three types. A coronary thrombosis may occur and may be followed directly by angina of effort, which may subside, with complete recovery from cardiac pain; alternatively, the angina of effort may be persistent. Another train of events may be as follows. A coronary thrombosis is succeeded by angina of effort which disappears, but a subsequent attack of illness of another type—for instance, influenza—may result in a recrudescence of the angina of effort symptoms. In other cases coronary thrombosis may be followed by angina of effort which, although it improves very gradually up to a point, never completely disappears.

Prognosis

The death rate of the whole group was 22 per cent.; in the private cases this was 28 per cent. and in the hospital cases 19 per cent. Table III and the chart give the

TABLE III

Years ..	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	11-12	14-15	19-20	Totals
Alive ..	24	19	14	8	6	7	2	2	1	2	1	1	1	88
Dead ..	6	10	2	2	3	0	0	1	0	0	0	0	0	24
Total ..	30	29	16	10	9	7	2	3	1	2	1	1	1	112

number of years between the first onset of the symptoms and the date on which the patient died or was last seen; the chart thus shows graphically the length of life either

Chart showing the number of years from the onset of the symptoms to the date on which the patient died or was last seen. Shaded areas = patients alive; black areas = patients dead.

from the first onset of angina of effort or from the onset of a coronary thrombosis which was followed by a period of angina of effort; in two of the patients giving the latter history the pain cleared up completely. Since the history only extends up to a period of two years in a large number of cases it is clear that the data as regards duration of life are not complete. But it is equally evident, taking into account the age of the patients, as shown in Table I, and considering this in relation to the survival figures, that the survival rate is not far short of that which would be expected for patients of that age without angina of effort but with evidence of cardiovascular disease. The death rate is: for the first year 20 per cent., for the second 35 per cent., for the third 12 per cent., for the fourth 20 per cent., for the fifth 33 per cent., for the sixth and seventh *nil*, and for the eighth 33 per cent. The series is, of course, too small for any definite conclusion to be drawn, but the figures appear to indicate that the chance of death is more or less the same for a patient with angina of effort during each of the first five years. A point that needs to be stressed is that *death in an attack of angina of effort is not recorded in the present series*, and it would therefore seem that *angina of effort is of itself not a dangerous symptom*, but that it is an indication of a greater or lesser degree of coronary disease. Only one patient died in pain, and a careful history of the attack, taken from an intelligent friend who was with him throughout, leaves little doubt that this patient had been seized with a coronary thrombosis early in the morning, and that death occurred while he was endeavouring to

remain up and about, later in the day. Of the twenty-five deaths four were from non-cardiac causes, in five the cause was unknown, and sixteen resulted from cardiac causes.

These conclusions would seem to indicate that "angina pectoris"—to use the inaccurate and general label—is not a dangerous symptom; for death does not occur during the attack of pain, and except in so far as it is the manifestation of a terminal coronary thrombosis the pain itself is not the fatal condition it is so commonly thought to be. This being so, it is the duty of the medical profession to discard the attitude of terror and taboo which is still so prevalent when dealing with and discussing this symptom, and to teach the general public that "angina" is in most cases not a dangerous or fatal condition; that, on the contrary, it is compatible with many years of useful life and is amenable to treatment; that danger is only to be feared from the underlying vascular disease.

Factors Influencing Prognosis

It can be said at once that the numbers in this series are too small for any accurate statistical analysis, but the following facts appear to emerge. Cardiac asthma, as would be expected, is a dangerous symptom, for all three patients died within two years. Abnormalities in the T wave of the electrocardiogram in Leads I and II seemed to be the next most serious finding. Seven out of ten patients in whom the T wave was inverted in Lead I or Lead II, or both, died, and two out of three patients died in whom the T wave was diphasic in Lead I or II. Thus nine out of thirteen patients with abnormalities of the T wave in Leads I and II died. This abnormality was not the transient electrocardiographic change of coronary thrombosis, but was persistent and permanent. Dyspnoea on exercise of a moderate degree was not more common in patients who subsequently died; not enough evidence was obtained that the presence, the absence, or the degree of dyspnoea resulting from exercise was helpful in prognosis. Coronary thrombosis is obviously likely to be a common cause of death in this group; but it is remarkable that the twelve patients in whom angina of effort started with a coronary thrombosis all remain alive. Active syphilis produced death in two cases out of eight; a third syphilitic patient died, but with coronary thrombosis in an atheromatous vessel. Diabetes appeared to make no difference to the prognosis.

It would thus seem that the cardiac prognosis ultimately depends upon whether or not a fatal coronary thrombosis is likely to develop, and upon the state of the left ventricular muscle. The only safe guide to determining this second point would be the amount of exercise that such a patient can undertake. This is of course generally restricted by the exercise pain. Some patients, however, can on some days undergo far more exertion without suffering pain than they can on others, and in these circumstances ability to climb hills or to walk reasonably well during a painless period is the most valuable prognostic point obtainable. Other complications of vascular disease, such as cerebral thrombosis, may prove fatal; this occurred in four cases in the present series.

Conclusions

1. Angina of effort is a clear-cut and definite symptom.
2. Angina of effort is associated in a very high percentage of cases with provable organic cardiovascular disease.

3. In our opinion, taking into account the impossibility in some cases of proving during life that coronary disease exists, angina of effort does not occur without coronary disease, except possibly in some cases of severe anaemia.

4. This coronary disease may be severe or slight, and probably in the majority of cases does not cause obstruction to the blood flow in the resting heart, but produces its effect by interfering with the normal stretching of the coronary arteries which occurs during exertion.

5. Angina of effort is in itself not a dangerous symptom: patients do not die in an attack. Danger is only to be apprehended from the occasional occurrence of coronary thrombosis, from the results of coronary atheroma on the ventricular muscle, or from other vascular accidents.

REFERENCES

- Bourne, G. (1935). *British Medical Journal*, 1, 1109.
 — (1937). *Ibid.*, 1, 695.
 — (1936). *Lancet*, 2, 551.
 — Scott, R. B., and Wittkower, E. (1937). *Ibid.*, 2, 609.
 Cabot, R. C. (1926). *Facts on the Heart*, 1st Ed., p. 555, Philadelphia.
 Elliott, A. H. (1934). *Amer. J. med. Sci.*, 187, 185.
 Heberden, W. (1785). *Med. Trans. Coll. Phys. Lond.*, 3, 3.
 Lewis, T. (1932). *Arch. int. Med.*, 49, 713.
 Willius, F. A., and Giffin, H. Z. (1927). *Amer. J. med. Sci.*, 174, 30.
 Wittkower, E. (1937). *Lancet*, 2, 665.

THE SHORTAGE OF CALCIUM IN THE "POORER-CLASS" DIET

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Certain routine tests carried out in this laboratory gave results which emphasized the fact that the ordinary diet of the poorer classes, consisting largely of bread, margarine, jam, potatoes, some meat, and a little milk and fresh vegetables, might be seriously deficient in bone-forming elements. An experiment designed to test this point has amply confirmed the suspicion.

Simpson and Wood (1935) investigated the influence of supplements of (a) cod-liver oil, (b) halibut-liver oil plus dried milk, and (c) virol to the diet of children attending various infant welfare centres in a typical London area. The children were mostly from working-class homes, and their diet was not controlled by the investigators. The doses of the three supplements were adjusted so that each child received an additional 75 calories a day. The amount of vitamin D received daily as cod-liver oil by each child was 2,080 international units, contained in 8 grammes of oil, which was therefore a very rich sample. (The *British Pharmacopoeia* 1937 Addendum requires a minimum vitamin D content of 85 international units per gramme.) The dose of halibut-liver oil gave approximately three and a half times as much vitamin A (as judged by "blue units") and a quarter as much vitamin D as the dose of cod-liver oil. Since the daily dose of halibut-liver oil was only 0.2 gramme, an extra half-ounce of dried milk was given to bring the calorie value of the total supplement up to that of the cod-liver oil supplement. The daily dose of virol was 20 grammes, stated to have a