An Evaluation Protocol for Fighter Aircrew with Non Specific ST-T Abnormalities

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Abstract

TWENTY aircrew with nonspecific ECG abnormalities were selected for study. Electrocardiograms were recorded at rest, in lying and standing positions, after Masters Double Two-step exercise, during and after submaximal and maximal treadmill exercise, during and after hyperventilation and valsalva manoeuvre, under hypoxia at rest and after Masters Double Two-step exercise, during tilt table studies and during/after +Gz stress. All such electrocardiographic investigations were repeated after administration of Beta blockers (Propranolol).

Majority of nonspecific ST-T changes were recorded in the inferior wall leads—at rest and after Masters Double Two-Step exercise. ECG recording after administration of propranolol showed reversal to normal in eleven cases. This group showed ECG changes suggestive of vasoregulatory syndrome. Two cases in this series are still under follow up to exclude ischaemic heart disease. Three cases showed postural correction of T-inversion. In the remaining four cases the exact nature of ST-T abnormalities could not be established. The role of other stress tests and value of Beta blockers in cases of non specific ECG abnormalities have been discussed.

Introduction

The presence of IHD is a grave risk to aircrew due to the possibility of sudden incapacitation while flying. Thus, early detection of IHD among aircrew becomes an imperative requirement. Routine ECGs are being taken for all aircrew at entry and also later on as a follow up at regular intervals. Some of these aircrew show changes in ECG both at rest and after exercise, which are non-specific in nature. A large number of such cases remain under observation for a long time, in the absence of a definite diagnosis. It has been a problem to decide about their flying fitness. In view of this, a detailed evaluation of such "asymptomatic nonspecific ECG abnormality" with various stress tests available at IAM was carried out in order to establish and outline a standard programme of evaluation of these cases for early diagnosis and disposal.

Material and Methods

Twenty aircrew with asymptomatic non specific ECG abnormality were selected for this study. The nonspecific ECG abnormalities included in this series consisted mainly of T wave changes such as :

(*i*) T wave of low amplitude

(*ii*) Flat T-wave

(*iii*) Inverted T waves in inferior leads II, III and aVF either singly or collectively

(*iv*) Inverted T in the antero-septal chest leads V1 and V2

(*v*) 'J' depression of ST segment by less than 1 mm.

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Detailed history with special reference to IHD, diabetes mellitus, hypertension and addiction to smoking or alcohol was elicited from each subject. General and systemic examination was carried out to exclude any organic illness. Investigations like Hb%, TLC, DLC, ESR, urine RE and ME, blood urea, uric acid, serum cholesterol, Standard GTT, serum sodium, potassium, X-ray of the chest and Tilt Table studies were carried out in all cases. ECG recordings included the following :

(*i*) A 14 lead resting supine ECG

(*ii*) 14 lead ECG in standing position

(*iii*) ECG (V5) before, during and after hyperventilation for 3 minutes

(*iv*) ECG (V5) before, during and after valsalva manoeuvre

(*v*) ECG after Masters Double Two- Step Exercise

(*vi*) ECG during and after submaximal and maximal treadmill exercise

(*vii*) ECG at rest and after Masters Double Two-Step Exercise at simulated altitude of 15000 ft (under hypoxia).

(*viii*) ECG before, during and after exposure to +Gz stress

All the above tests were repeated after the officers were administered Propranolol 40 mg tds for three days. The investigations were spread over a period of twelve days for each subject.

Results

Seven cases were moderate smokers (less than ten cigarettes per day). None of them were addicted to alcohol, though they consumed occasional drinks (2–3 pegs) in social gatherings. Age varied between 30–34 years. None was obese. General and systemic examinations did not reveal any abnormality. Biochemical parameters and X-ray chest were normal in all the cases.

Breakdown of various ECG abnormalities i twenty cases is given in Table-1.

TABLE 1

E. C. G. Abnormalities

Abnormality	No. of case
T inverted in III, III (R). aVF upright in aVF (R)	2
T inverted in II, III, aVF, aVF (R)	1
T inverted in II, Biphasic in aVF	1
T inverted in III, III (R) aVF and Biphasic in aVF (R)	2
T inverted in III, Biphasic in III (R) aVF, aVF (R)	2
T inverted in III, III (R). Flat in aVF and Biphasic in aVF (R)	2
T inverted in III, III (R). Isoelectric in aVF, aVF (R)	1
T Isoelectric in I, aVL, V3, V4, V5 and V6 inverted in III and aVF	1
T Isoelectric in III, upright in III (R), aVF, aVF (R)	2
Low voltage T in II, III, aVF and Isoelectric T in aVF	2
Normal resting ECG, but after DMT, T becomes Biphasic in III, upright in aVF with 'J' depression	2
Normal resting ECG, post exercise ECG shows T inverted in III, Isoelectric in aVF, T inverted in V2, V3 with 'J' depression of ST segment	1
T inverted in V1 and V2	1
Total	20

The localisation of E.C.G. abnormalities and evaluation after propranolol are given in Table 2.

TABLE 2

Localisation of ECG Abnormalities and Evaluation after Propranolol

Area of involvement	Pre drug	Postural Correction	Post drug (Propranolol)		
			Corrected	Partially corrected	Not corrected
Inferior wall	19	3	10	2	7
Anteroseptal	2 (1 case with Inf. wall)	–	2 (1 case counted in Inf wall group)	–	–
Antero-lateral & lateral wall	3 (all 3 cases with Inf wall)	–	1 (counted in Inf wall group)	1 (counted in Inf wall group)	1 (counted in Inf wall group)
Total/Percentage	20/100%	3/15%	11/55%	2/10%	7/35%

Majority of cases (19 out of 20) showed inferior wall changes (Fig. 1 and 2). One case had antero-septal T wave changes. Two subjects had normal resting ECG. One subject with antero-septal and three cases with antero-lateral and lateral wall changes also had associated inferior wall changes. A typical recording is given in fig. 1. Repeat resting ECG after administration of Propranolol showed correction of inferior wall changes to normal in ten cases; partial correction was seen in two cases and no change from the resting ECG pattern was observed in four cases. Both cases with antero septal changes were corrected following propranolol administration. Out of the three cases with infero-lateral and antero-lateral changes one showed correction (Fig. 2) and one partial correction, after propranolol administration 55% of the total ECG abnormalities were corrected

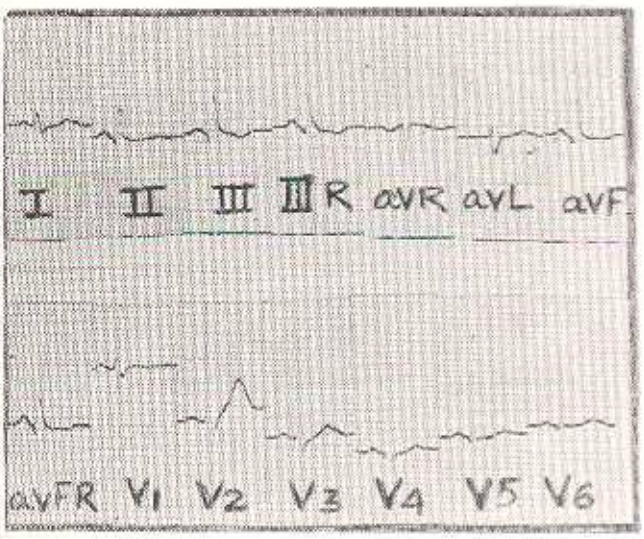

Fig. 1 Resting E C G showing inferior wall changes

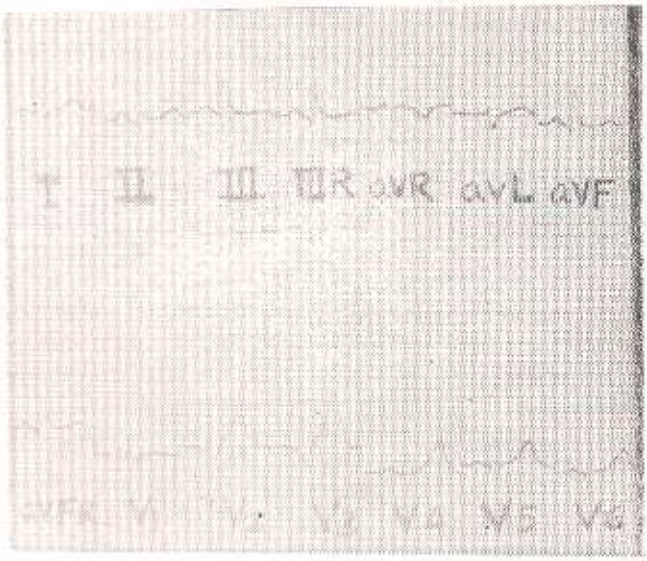

Fig. 2 Resting E C G showing correction of inferior wall changes after Inderal

with the drug. 10% showed partial response where as 35% did not show any response.

Three cases with T wave changes in inferior wall showed normalisation of the record on standing position (postural) one such recording is given in Fig. 3.

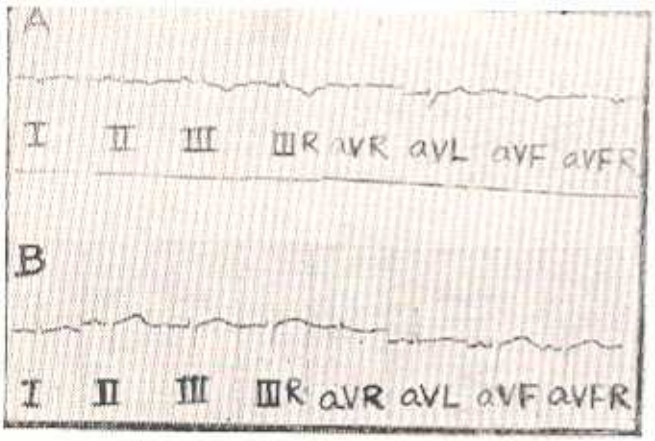

Fig. 3

Postural changes in E C G

(a) Resting E C G (Lying position)

(b) Resting E C G (Standing position)

ECG recorded during hyperventilation, and valsalva manoeuvre did not affect the T waves in any of the cases. Tilt Table studies were normal.

Table 3 shows the ECG abnormalities with DMT before and after administration of propranolol. In 14 out of 20 cases the ECG abnormality got corrected with the drug.

TABLE 3

DMT: Further Extensions of ECG Abnormalities

Changes seen	Pre drug	Post drug	
		Corrected	Not corrected
Antero-septal	6	4	2
Lateral wall	3	2	1
Inferior wall	1	1	Nil
ST sagging	3	2	1
Tall T in V2, V3	1	1	—
Low Amp of T in V5, V6	2	2	—
Low Amp of T & R	2	—	—
V P B	2	2	—
Total	20	14	6

Table 4 shows the effect of Submaximal/Maximal Treadmill stress on the ECG pattern.

TABLE 4

Submaximal/Maximal Treadmill Exercise

Changes seen	Pre drug	Post drug		
		Partially corrected	Corrected	Not corrected
Inferior wall	5	2	2	1
Inf. lateral & lateral	2	–	1	1
Antero septal	2	–	1	1
ST depression	3	–	2	1
Low voltage of T	1	–	1	–
Supraventricular ectopics	1	–	1	–

Table 5 shows changes in the ECG recordings observed after Masters Double Two Step exercise under hypoxia.

TABLE 5

Hypoxia Test (Extension seen)

Changes seen	Pre drug	Post drug	
		Corrected	Not corrected
Antero-lateral & lateral wall	5	4	1
Inferior wall	Nil	–	–
ST depression	3	2	1
Low amplitude T	1	–	1
Supraventricular ectopics	2	2	–
VPB	1	1	–

The effect of G stress on the ECG abnormalities before and after administration of propranolol is shown in Table-6.

TABLE 6

Acceleration Exposure (Extension seen) — Fig 4

Changes seen	Pre drug	Post drug	
		Corrected	Not corrected
Lateral wall	4	4	–
Septal	1	1	–
Inferior wall	Nil	Nil	–

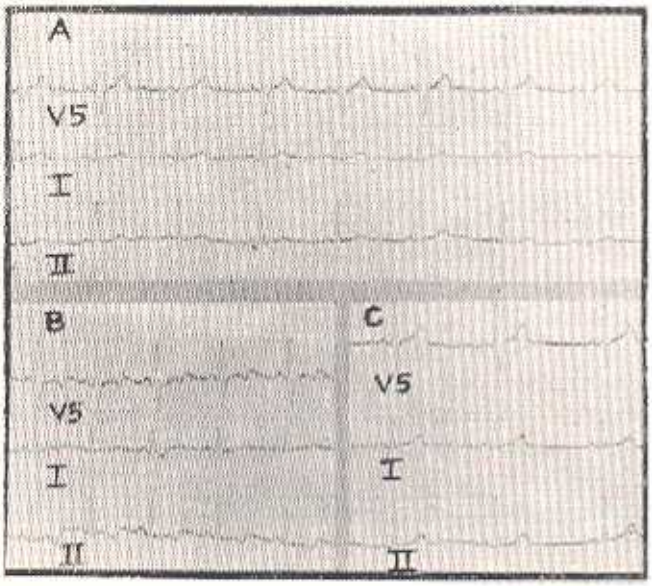

Fig. 4
E C G record during acceleration
(a) Resting record
(b) Record during Peak G
(c) Record during Peak G after Inderal

Cases were followed up from six months to two years and repeat ECG recording under the above stress tests showed no further deterioration except in two cases. These two cases are under lower medical category and observation.

Discussion

Approximately two thirds of patients with significant coronary artery disease documented by coronary angiography have a positive exercise ECG[8]. More severe the coronary terminal narrowing and greater the number of vessels involved, more is the likelihood of exercise ECG being positive. A positive exercise ECG in a normal person has also been shown to correlate with the subsequent development of significant coronary artery diseases[3,8].

Frolich[6] described a distinct clinical entity called "Hyperdynamic Beta-Adrenergic Circulatory State" and postulated that it was caused by the higher reactivity of the Beta-Adrenergic receptors to the usual stimuli and not due to excessive stimulation of these receptors. Palpitation is the main symptom in this group. In some it persists for inordinately long period following exercise. There is always an excessive rise of heart rate on standing up and a disproportionate tachycardia on exercise. The haemodynamic response to upright tilt and valsalva manoeuvre tests are normal. The hyper acute response to Beta receptors can be provoked by intravenous administration of Tyramin and Isopranaline infusions.

Gorlin and his colleagues[11] described a group of people with suspected heart disease and low physical wasting capacity due to inadequate adjustment of peripheral circulation and termed this condition as "Vaso Regulatory Asthenia." In these cases the essential haemodynamic disturbances a r e relative peripheral vasodilatation and a large blood flow. During work the excessive blood flow through other tissues remains unchanged, hence there is a relatively diminished blood flow through the working muscle from the given cardiac output. Such cases showed orthostatic changes on ECG in the form of ST depression and diminution of T-wave amplitude or T-wave inversion in the erect posture.

Nordenfelt[20] and Furberg[9] reported correction of nonspecific ST-T changes by use of Beta Adrenergic blocking agent (Propranolol) as opposed to cases of coronary insufficiency and post myocarditis syndrome. ECG changes were thought to be due to excessive sympathetic activity. It is important to recognise this identity, otherwise ST-T changes during exercise may be misinterpreted. The ST-T changes are usually confined to the inferior or inferior and lateral leads, occassionally in leads I, and aVL and inversion of T waves in all the precordial leads. Correction of ECG abnormalities following propranolol have also been described by several workers [5, 10, 14, 16, 24, 26]. Khanna et al[14] reported aggravation of ST-T changes by valsalva manoeuvre, which was reported to be normal by Friesinger et al[5]. In our series 11 cases (55%) fit in the diagnosis of vaso regulatory abnormality. Smith et al[24] have recorded the return of abnormal T wave patterns in 17 of 25 cases with clinical evidence of cardiovascular reactivity. In the remaining cases it may have been a combination of cardiovascular reactivity and coronary atherosclerosis.

The value of Propranolol as a diagnostic tool for separating functional from organic diseases seems to have a reasonable clinical basis. Stress induced catecholamine liberation can produce physical signs and ECG changes comparable to changes associated with organic cardiovascular disease. Beta blockers reduce the force of myocardial contraction and de-

crease the cardiac output and heart rate. Since there is an overall reduction in the function of the myocardium, this also reduces the oxygen requirement of the heart[19]. Consistent with myocardial ischaemia, ectopic beats, arrhythmias along with T-wave inversion and R-ST segment displacements have been observed in situations associated with stress, both physical and mental. Since the input of catecholamines acting upon a normal myocardium was so intense that it produced ischaemic changes in the electrocardiograms, obviously removal of the stress would reverse the pattern. If however, reversal of the R-ST segment and T-wave changes were not affected, then we could hypothesize that significant atherosclerotic changes or stenosis were present regardless of catecholamine concentration.

Hiss et al[12] found 581 cases of non specific T wave changes in the ECG survey of 67,375 healthy males of various ages of flying status in US AF. In this study, low T-wave amplitudes in both limb and lateral precordial leads without widening of the RS-T angle increased significantly with age. IHD as the underlying causal factor for these ECG changes could not be proved. Leftward rotation of the T-Vector in the frontal plane and left axis deviation of QRS axis may produce T-wave changes in lead II, aVF as well as V4, V5 and V6[26]. Bloom[2] has described fear, gun shot startle, psychiatric patients with emotional reaction, cardiovascular neurosis, hyperventilation, hypoglycaemia, tachycardia, insulin shock therapy, administration of adrenergic drugs, female hormones and psychosis as some of the extra cardiac causes producing non specific ECG changes.

Exercise in hypoxia chamber is yet another non-invasive test being used for screening of ischaemic heart disease. Khanna et al[14] and Frolicher et al[7] have used this test for evaluation of cases of ischaemic heart disease. In our series a total of fifteen abnormal ECG changes were seen under hypoxia and exercise under hypoxic environment. Repeat test after Propranolol administration showed correction of all the abnormalities including ventricular and supraventricular ectopics, except the two cases, which after his test were considered to be due to IHD.

Effects of positive Gz on the cardiovascular system have been studied in detail by many workers[11, 21]. Various mechanisms have been postulated for the production of arrhythmias under +Gz stress viz variation in the tone of extra cardiac nerves, variation in the filling of the individual chambers of the heart. Changes in the position and configuration of the heart during acceleration and other stresses and emotional factors like anxiety causing catecholamine effect. Rai et al[21] consider the inversion of T-wave during + Gz exposure to be mainly due to increased sympathetic tone which is corrected by Beta blocker. Krishnamurti et al[17] have issued a word of caution while interpreting ECG changes under acceleration forces due to sudden change in the environmental condition for the heart. Khanna et al[15] in their studies of +Gz stress on subjects with vaso regulatory abnormality before and after administration of Beta blockers, have reported prominent P-waves, inversion of T waves and minimal ST segment depression. These returned to normal after Beta blockers and hence ischaemia as a cause of these changes was ruled out.

In the present series we have been able to find T wave changes during acceleration stress in four cases which have been corrected after the administration of Propranolol. In none of our cases we have seen significant P-wave or ST segment changes. No arrhythmias were recorded either.

Conclusion

Beta blocker (Propranolol) in this series, though has led to the diagnosis of vaso-regulatory abnormality in more than 50% cases, has not provided definite means of exclusion of ischaemic heart disease. It is felt that repeated assessment and periodic follow up of such cases will be more rewarding in diagnosis of ischaemic heart disease than Propranolol alone.

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References

1. Balasubramanian, V., Khanna, P.K., & Hoon, R.S. On-line Digital Computer Quantitated ST Segment Response to Sub-Maximal Treadmill Exercise. Journal of the Association of Physicians of India. 23, 1, 1-8, 1975.

2. Bloom, G.E. A review of Electrocardiographic changes in emotional stress. J. Nerves and Med. Sci. 201, 693, 1941.

3. Bruce, R.A. McDonaugh, J.R. Stress testing in Screening for Cardiovascular Diseases. Bull. N.Y. Acad. Med. 45, 1288-1305, 1969.

4. Chatterji, J.C., Das, B.K., Akhtar, M. Electrocardiographic Abnormalities in Air Force Personnel Aviation Medicine, XXII, 1-34, 1978.

5. Friesinger, G.C., Bieru, E.O., Lilar, I. and Mason, E.S. Exercise Electrocardiography and Vasoregulatory Abnormalities. Amer. J. Cardiol. 30 : 731, 1972.

6. Frolich, E.D., Dustan, N.P. and Page, G. Hyper Dynamic Beta Adrenergic Circulatory State. Arch. Intern. Med. 117, 614-619, 1966.

7. Froelicher, V.F., Thomas, M.M., Pillaw, S., Lancaster, M.C. Epidemiological study of Asymptomatic Men screened by Maximal Treadmill Testing for Latent Coronary Disease. Amer. J. Cardiol. 34, 770-776, 1974.

8. Ferlinz, J., Aronow, W.S. Comprehensive Approach to the Diagnosis and Evaluation of Coronary Artery Disease. Journal of Applied Med. 3, 717, 1977.

9. Furberg, C. Adrenergic Beta Blocker & Electrocardiographic ST-T changes. Acta Med. 181, 21-32, 1967.

10. Gandhi, M.J. Patients with Angina Pectoris and Normal Coronary Arteriograms (letter to the Editor) Amer. J. of Cardiol. 34, 818-819, 1974.

11. Gorlin, R.I. Thy Hyperkinetic Heart Syndrome. J.A.M.A. 182 : 823, 1962.

12. Hiss, R.G., Averill, K.H. & Lamb, L.B. Electrocardiographic Findings in 67, 375 Asymptomatic Individuals — Part VIII, Non-Specific T-wave changes. The First International Symposium on Cardiology in Aviation. 329-346 1959.

13. Hoon, R.S. Incidence of Cardiovascular Problems Among Flying Personnel & their Evaluation. Aviation Medicine XXII : No. 1, 1978.

14. Khanna, P.K., Dham, S.K., Hoon, R.S. Exercise in an Hypoxic Environment as a Screening Test for Ischaemic Heart Disease. Aviation Space and Environmental Medicine 47 : 1114-1117, 1976.

15. Khanna, P.K., Balasubramanian, V. Satish, K. Dham, Kuldip Rai & Raghunath Singh Hoon. Effect of Positive Acceleration (+Gz on Electrocardiogram of subjects with Vasoregulatory Abnormality. British Heart Journal 38, 317 — 322, 1977.

16. Krishnamurti S., Balasubramanian, V., Cheema, B.S., Durai Raj, M & Hoon, R.S. Beta Adrenergic Blockade — A simple Test for Evaluation of the Significance of Inverted "T" waves. Journal of J.J. Group of Hospitals and Grant Medical College. XXVIII, No. 3, 91-95, 1973.

17. Krishnamurti, S., Sundaram, P.M. & Singh, V. Positive "G" Effects on ECG. Journal of Aero Medical Society of India. 1, 1971.

18. Master, A.M. & Rosefeld, I. Criteria for the application of the "Two Step" Exercise Test. J.A.M.A. 178 — 183, 1961.

19. McKee, E.B., Smith, J.S. & Kidera, G.J. Beta Adrenergic Blockade — An Aid in Diagnosis. Aero Space Med. 40(6) : 662 — 667, 1969.

20. Nordenfelt, O. The Orthostatic ECG changes and the Adrenergic and Beta Receptor Blocking Agent, Propranolol (Inderal). Acta Med. Scand. 1978 : 393-401, 1965.

21. Rai, K., Dham, S.K. Effects of Propranolol on (+Gz) Journal of Aeromedical Society 16 : 1, Oct. 1973.

22. Roland, G., Hiss, R.G., Lamb, L.E., Margaret F. Allen Electrocardiographic Findings in 67, 375. Asymptomatic Individuals Part X — Normal value — The First International Symposium on Cardiology in Aviation : 362-409 — 1959.

23. Singh, I., Khanna, P.K., Srivastava, M.C. & Hoon, R.S. Extent of Possible Rehabilitation of Service Personnel with Ischaemic Heart Disease. British Heart Journal — 32 : 665, 1970.

24. Smith, J.E., McKee, E.B., & Kidera, G.J. Studies of the Effect of Beta-Adrenergic Blockade on Abnormal R-ST Segment & T wave changes. Aerospace Medicine — 41, 2, 190-195, 1970.

25. Sainani, G.S., Beta-Adrenergic Blockade. A Simple Test for Evaluation of the Significance of Inverted "T" waves. Journal of J.J. Group of Hospitals and Grant Medical College, 18, 1972.

26. Smith, J.E. & Kidera, G.J. Effect of Programmed Exercise on Non-Specific T-wave Abnormalities. Aerospace Medicine 39 : 528 — 532, 1968.