AIR MARSHAL SUBROTO MUKHERJEE MEMORIAL ORATION 1977

Incidence of Cardiovascular Problems Among Flying Personnel and their Evaluation

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I TAKE this opportunity to pay homage to the memory of late Air Marshal Subroto Mukerjee who through far-sight, high ideals, exceptional professional skill and personal qualities worthy of being emulated, earned for himself and for our Air Force the highest respect and esteem at national and international levels. I next offer my congratulations to succeeding Service and Medical Air Force authorities for the wonderful manner in which they have continuously striven to meet the developing challenges of time. They have thus attained the present high levels of efficiency in service, health and medical care. Lastly, I thank the Aeromedial Society for the honour done to me by nominating me to deliver this year's Subroto Mukerjee Oration.

Cardiovascular problems, the topic of my address, have steadily grown through the recent decades to the present disturbing level throughout the world. The magnitude of their threat, to highly skilled persons in general and to the aircrew in particular, has been universally recognised. In this developing pattern, the explosion of knowledge in the fields of science and technology has acted as a double-edged weapon. On the one hand it has enabled the aeronautical engineers to produce successive generations of aircraft with better performance, continuing refinement and progressive sophistication. The size, the appearance, the operational speed, altitude and the impressive array of electronic devices in the cockpit bear ample testimony to their achievements. Innovations to endow the machines with special capabilities tailored to specific needs in civilian and service roles have opened up new vistas for the contemporary aircrew. As an inescapable by-product of these developments, the standards of health, alertness and endurance have progressively become more and more exacting. The hazards from actions lacking in judgement, speed or accuracy in execution have tremendously increased. The cumulative effect of these developments has been to make the task of the aeromedical authorities more challenging, complicated and demanding.

On the other hand, the tremendous advances in medical electronics and bio-medical engineering have helped the aeromedical authorities in getting a clearer understanding of myocardial function and haemodynamic phenomena at rest, under stress and in various disease states. Detection of disease and dysfunction has been made much more sensitive –their evaluation much more accurate. The role and outlook of the medical sciences have been revolutionised from "Meeting the Catastrophe" to "Preventing the Incident". In the context of these developments, consideration of the incidence of cardiovascular problems, our machinery and methods of dealing with them and suggestions for modifications in the light of advances in the developed countries provide ample food for thought.

Incidence

A reasonable estimate of the incidence can be made by consideration of three parameters i.e. hospital admissions, invalidment from service and mortality data.

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Hospital Admissions

In 1972, the total admissions to hospital on account of ischaemic and other heart diseases was 2.4 per thousand. This constituted approximately 3% of the total admissions on account of preventable medical diseases including stress and metabolic disorders. In 1976 admissions for cardiac and preventable medical diseases were 2.5 per thousand. In the intervening three years too, there was no statistically significant difference in the pattern of admissions—the cardiac conditions accounting for nearly 3% of the total medical diseases specified above.

Invalidment

No Air Force Officer was invalided from service on account of ischaemic or other cardiac diseases during the five years period, 1972 to 1976. In respect of the airmen, however, 4–5 per cent of the annual invalidment was due to cardiovascular diseases.

Mortality

In 1972, amongst Officers, 83% of all deaths from medical conditions were due to ischaemic or other heart diseases. The figures for the succeeding four years were as follows:

1973	:	75%
1974	:	88%
1975	:	100%
1976	:	100%

It is true that the numbers were small as the total deaths during any of the years under consideration did not exceed 9. The high component of the cardiovascular diseases, however, merits careful analysis and stringent remedial measures.

In respect of the airmen, in 1972, cardiovascular diseases accounted for 50 of the total deaths from medical causes. The figures for the four succeeding years were 51, 53, 44 and 40 per cent respectively.

It is reasonable to conclude from the above data that;

(a) admissions to hospital and invalidment from service need not evoke any serious concern.

(b) The mortality figures for the airmen have shown a significant fall during the past two years. They, however, still remain in the zone which should not be considered as acceptable.

Ischaemic Heart Disease

It is generally agreed that the single entity causing major portion of morbidity and mortality attributable to the cardiovascular group is ischaemic heart disease presenting as sudden death, angina, ECG abnormality, arrhythmia, failure or various other symptom complexes. Active and effective control of ischaemic heart disease, therefore, forms the core of any plan or programme for preventing loss of man-power or man-hours through cardiovascular disorders. High Index of suspicion, energetic preventive measures, including education and follow up of risk factors, timely therapy and effective rehabilitation have paid rich dividends in the past and offer considerable hope for the future.

Early Detection

Einthoven's discovery of the Electrocardiograph in the beginning of the current century provided a sensitive tool for objective assessment of the ischaemic episodes clinically described by Heberden well over a century earlier.

Routine ECG, has, however, not proved an unmixed blessing. Undue attention to minimal deviations from the accepted norms has produced a number of cardiac neuroses and led to unfair termination of the flying career of healthy and highly skilled aircrew. Failure to detect changes in the areas beyond the range of the electrodes or sensitivity of the machine have had tragic consequences. Despite all precautions, the sensitivity and specificity of the ECG have remained controversial. It is universally agreed, however, that despite its limitations, routine ECG examination and its refinements are of unquestionable value if the "cost" of training of aircrew is kept in mind. The Canadian authorities insist on it even though the rejection rate on the basis of ECG alone is around 0.5% only. In a careful study under auspices of the Armed Forces Medical Research Committee, analysis of 5,000 successive electrocardiograms of asymptomatic Air Force personnel showed possible inchaemic pattern in 1% and non-specific ECG abnormality in 2%. Considering that it takes 6–7 years intensive training at a cost of 6–7 lakhs of rupees before a new entrant becomes a fully operational pilot, ECG screening is vital not only for detecting unfit cases but also to provide a base-line graph for future reference. This is in conformity not only with the policy of the Canadian Authorities but also with the consensus of world opinion.

Stress Testing

Published reports on the scope and limitations of Stress Testing have been very variable and often conflicting. Borer and Brensibe, Martin and Mc Conahay, Redwood and Borer from the National Institute of Health reported very poor correlation between the stress test results and the degree of coronary artery involvement. The methodology, criteria and conclusions of these workers have been contested on several counts. On the other hand, Zohmann and Kattus at the Medical Centre, Cardiac Services found stress testing very sensitive and specific in evaluating cases of coronary artery disease. They recommended maximal stress and collective consideration of clinical, haemodynamic and ECG data in evaluating doubtful cases. Bartel and colleagues obtained positive stress tests electrocardiograms in 77, 66 and 53 per cent of cases with three, two and one coronary artery disease respectively. Ellestad and Halliday consider that, though by no means perfect, the technique of Stress Testing is at this time the single, best, non-invasive method for establishing the presence of coronary artery disease. They found it positive in 80, 75 and 53 per cent of those with three, two and one vessel disease respectively.

In our Stress test laboratory at Army Hospital, Delhi Cantt, we took note of both points of view and undertook as objective an evaluation as possible. After the first one hundred consecutive tests carried out on 70 patients we were impressed by the value of this investigation in assessing cases of coronary artery disease. We also drew attention to the advantages of the technique on the one hand and its pitfalls and sources of error on the other. During subsequent tests carried out alone or for comparative study with other techniques e.g. hypoxic exercise test, transthoracic impedence plethysmography, plasma fibrinolytic activity, we consistently encountered impressive realiability, sensitivity, and specificity. Over 1500 successive tests carried out on cases closely followed up during the past four years, have enabled us to confidently state that we are in general agreement with the views of Ellestad and Halliday i.e. Stress Testing carried out with due precautions, is a very valuable non-invasive technique for establishing the diagnosis and for predicting the prognosis in cases of Ischaemic Heart Disease.

Electrical Impedance Plethysmography :

Basic Principle : It has been shown that the conductance of biologic tissues depends upon their ionic content. As the number of ions contained in a known volume of water is constant, it is theoretically possible to determine the volume and fluid content of tissues interposed in the path of current of known specifications. The technique actually employs alternating current and measures the drop in voltage due to the resistance (impedance) of the intervening structures.

In our studies in the initial stages the fixed impedance (Zo) was measured. Subsequently, however, the first derivative of the impedance wave form (dz/dt) was studied in detail and found very useful in evaluating cardiac function, haemodynamic status and fluid content of various organs/compartments. Our experience in respect of both parameters is briefly described in succeeding paragraphs.

Transthoracic Electrical Impedance (TEI)—Zo. In our study of heamodynamic changes on exposure to high altitude, we found that serial estimations of TEI were very useful and dependable for early detection and follow up of cases of high altitude pulmonary edema. The physician was alerted to look carefully for changes in the thoracic fluid volume by a drop in impedance. Conversely return of impedance towards normality was shown to parallel improvement in the clinical condition and heamodynamic state of cases of high altitude pulmonary edema.

It will be recalled that pulmonary congestion resulting from left ventricular dysfunction has been demonstrated in cases of ischaemic heart disease during anginal attacks. It was, therefore, considered that on theoretical grounds, changes in TEI from the resting figures should give some clue to the alterations in cardiac function and haemodynamic status. We, therefore, estimated TEI in the following three groups ;

(*a*)	Normal Controls	20 subjects
(*b*)	IHD with angina during stresss testing.	15 cases
(*c*)	Asymotomatic cases with diagnostic ST depression during stress testing.	17

It was observed that in normal healthy controls, the TEI showed either an insignificant fall or a moderate rise as the stress test proceeded. There was

immediate return to normal levels on cessation of exercise.

In cases of ischaemic heart disease, the TEI dropped steadily and significantly as the exercise progressed. On cessation of the exercise, the TEI did not return to normal immediately. The changes in the cases who developed anginal pain during the test were more profound and longer lasting than in those who developed asymptomatic ST depression.

In subsequent comparative studies of the Hypoxic Stress Test, the Sub-maximal Exercise Test and TEI we have been impressed by the reliability and reproducability of this simple, safe, non-invasive bedside technique.

The Wave Form (dz/dt) : The first derivative of the impedance (wave form) closely simulates the carotid pulse. Its simultaneous recording with the ECG and the phonocardiogram affords reliable data for computing the stroke volume, cardiac output and systolic time intervals thereby giving important information regarding myocardial contractility and haemodynamic status. In our experience these data could be obtained from the impedance wave form with greater ease, speed and acuracy than from conventional techniques like carotid pulse. It is generally agreed that there is acceptable correlation between these non invasive data and those obtained directly through the invasive techniques.

Reference to literature on the subject shows that Chung's 1976 edition of "Non-intvasive Cardiac Diagnosis", Michael Crawford's list of non-invasive techniques in March, 1977 issue of Angiology and Zohmann's article on Stress Testing in the August 1977 issue of American Journal of Cardiology do not mention TEI as a diagnostic non-invasive technique. From other centres too reports are few and the sample size small. In our opinion the technique is useful and particularly suited to our resources and requirements. It merits being explored further.

Other Diagnostic Techniques

Continuous ambulatory ECG monitoring has been helpful in establishing the diagnosis of ischaemic heart disease in some cases in whom resting and stress electrocardiograms had been negative or equivocal. Radionuclide imaging may demonstrate alterations in myocardial perfusion at rest and after exercise. The technique of gated blood pool scanning has been reported of value in showing abnormal motion of ischaemic left ventricular wall. The standard M-Mode Echocardiagraphy and its various refinements can be used for a closer study of selected areas. Videotracking of the cardiac silhouette has been reported to be more effective and convincing than the routine fluoroscopy. Displacement cardiography has been recently introduced as a simple, safe, easy and non-invasive technique for study of myocardial contractility. The technique is still under trial but appears to be promising.

In the invasive field, cardiac catheterisation ventriculography and selective coronary angiography are being used in selected cases especially the candidates for coronary by-pass surgery. There is, however, legitimate apprehension about advocating these techniques for determining "fitness for flying."

Disposal

During the period Oct 73 to Dec 77, 82 Officers aircrew and 99 ground duty officers were referred to the Unit of Senior/Chief Consultant in Medicine to the Armed forces for opinion in respect of diagnosis and/or disposal. Of these 181 cases, 12 were awarded full flying category, 14 full ground duties and 45 restricted flying category. The groups awarded flying categories may now be considered briefly. Seventeen officers were awarded Category A3. Eleven of them had ECG abnormality as follows :-

WPW Syndrome	—	3
VRA	—	3
VPC	—	2
Non-specific T wave changes	—	3

Of the remainder, one had mild mitral regurgitation, the other five had IHD. One of these "IHD Cases" posed a problem by virtue of his history, findings and progress. A heavy smoker complained of pain in the sternal region and cough. His ECG showed VPCs. The admitting MO interpretted the chest pain as anginal. The pain and the VPCs cleared up on stopping smoking and therapy for mild chest infection. Subsequent investigations including stress testing and studies in hypoxic chamber failed to reveal any abnormality. Higher category was, however, withheld in view of the initial diagnosis of angina and the VPCs. This may be considered as a case of hardship of iatrogenic origin. In the absence of coronary angiography, however, a firm stand, could not be taken.

During the same period, eight Air Force Officers were upgraded to medical category A2G1. The diagnosis was IHD in 3, VRA in 2 and Hypertension, WPW Syndrome and EGG abnormality in one each.

Nine Air Officers were awarded medical category A1G1. One of them had RBBB, two VRA and one a short PR in association with abnormal GTT. Marked clockwise rotation was the only ECG abnormality in another case. He subsequently developed a mediastinal mass due to sarcoidosis. Silent M.I. non-specific ECG abnormality and Qs were observed in one case each. These cases have been closely followed up for 3–4 years. None of them has shown any symptoms, deterioration of ECG pattern or of cardiovascular status. An interesting case was that of an Air Officer who had been under observation for labile hypertension and a small q in leads III and aVF. After a clean record of nearly ten years, he complained of pain in the chest. He was immediately grounded and hospitalised. After thorough investigations, he was found fit and returned to duty in category A1G1. This officer has been flying since his original examination in 1966.

Oct 73 may be considered as an important milestone in our programme of accurate diagnosis and evalaution of cardiac cases. The entire schedule was streamlined and made as objective as possible. The investigations were multipronged i.e. clinical, laboratory, stress testing, hypoxic exercise test and impedance plethysmography. Officers conducting investigations in one field were not aware of the findings of the others. Ultimately, however, all data were collectively considered and evaluated. Differences were resolved through reconsideration, repeat examination or further observation. This programme was well conceived as is borne out by two important facts among others :

(a) None of the fatal cases mentioned earlier had been cleared by this screening regime.

(b) Only one of the cases upgraded on the recommendation of the screening machinery had to be downgraded again. The initial diagnosis in this case was ECG abnormality with VRA and partial response to beta blockers. All other cases have maintained their progress while functioning in the allotted category.

In all our decisions, the principle considerations which weighed with us were operational efficiency and safety of crew, passengers and property. Our interest and involvement in this vital problem is shared by specialists in the field all the world over. The American College of Cardiology devoted two of the annual Conferences i.e. in 1965 and 1975 to topics related to cardiovascular problems and air safety. The highlights of these conferences were :—

(a) Recommending limitations.

(b) Recommending indications for re-licensing of aircrew with cardio-vascular diseases.

(c) Discussions of invasive and non-invasive diagnostic techniques.

(d) Re-evaluation of criteria in respect of non-specific abnormalities previously considered disqualifying.

The consensus was in favour of the Canadian policy which accepts base-line ECG as essential ; recommends preparation of risk profiles and inclusion of active health education of aircrew as a part of the preventive programme. They encourage Stress Testing but do not ground aircrew on the basis of a positive stress test alone.

In respect of Risk factors, KENNEL's study is very instructive. He has shown that when the risk factors rose from 1 to 3, the morbidity increased from 70 to 322 in the 400 subjects studied.

In our own Air Force, the policy in respect of risk factors has been laid down and other measures in operation since 1975. Family history; smoking and other aspects of personal history; results of physical examination, especially weight and blood pressure; the lipid profile and glucose tolerance have all been given due weightage. Stress Tests have been carried out when necessary.

In respect of disposal, our policy is in agreement with permitting RBBB and thiazide intake provided cardiovascular disease and dysfunction have been excluded. We, however, do not contribute to the Canadian line of thinking and have not cleared any case of RBBB for flying. Our approach in this respect is in general agreement with the consensus on the subject. In cases of congenital Heart disease and acquired aortic valvular disease we are more cautious

and conservative than the Canadian authorities. We have, however, not had any such cases for disposal.

In the context of the prevailing conditions, therefore, it is reasonable to sum up the requirements as being study of the causes, the course and the risks from cardiovascular problems. A safe logical and workable solution to these problems requires strict screening of new entrants, employing rigid criteria, and classification or elimination of those found unfit. The preventive measures should aim at identification of risk factors and education and follow up of concerned personnel in the light of their risk profiles. Therapeutic measures should include active and energetic rehabilitation to speedily restore the flying status to the aircrew, subject to flight safety and operational efficiency.

Suggestions

An investigational programme based on multipronged, objective and non-invasive methodology should be developed on a firmer footing.

The requirements of equipment and trained personnel may be worked out in the light of current developments in the field, the present holdings and their life/serviceability.

Base-line and periodic ECG should be continued in conformity with the world consensus and our own experience. All ECGs should be seen by at least one specialist trained in the technique and methodology. The logistics in respect of number and location of the machines/technicians will have to be worked out.

Conclusions

I firmly believe that in the conditions prevailing today, it is not possible to provide a first rate Aeromedical Service without judicious and intelligent application of the advances in the fields of electronic and biomedical engineering. I believe even more firmly, however, that if in the pursuit of fascinating and sophisticated gadgets we lose our clinical ability, humane approach and a close link with the men we have the previlege to have in our charge, the outcome will be retrograde, tragic and potentially disastrous. I am confident that our medical colleagues will continue to meet the challenges confronting them with able guidance, support and blessings of administrative authorities and through a balanced admixture of the science and art of healing, make the service a step better than the best in the world.

This, to my mind, will be the most befitting manner of redeeming our debt to all those who gave their lives in the selfless service of the Air Force and the country and paying a tribute to those who are now trying to maintain continuing progress through dedicated and devoted efforts.