



## (Problems in Aero-Medical Evaluation \*\*II)

### —Some Cases of ECG Diagnosis of Asymptomatic IHD Reviewed

FROM

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Stress-ECG is reported to be 60%—64% sensitive and 89%—93% specific for CAD in the clinical setting.<sup>19</sup> Nevertheless, the predictive value of CV stress-testing for occult CAD, amongst asymptomatic males, is only about 40%, if CA<sup>24</sup> or cardiac events are endpoints. The high false-positivity has serious implications on flying status of the individual as well as the organisation.

Out of 5693 ECG reports surveyed, for 15-year period 1968-1983, 72 totally asymptomatic, otherwise clinically normal, AF Aircrew and Civil Flight crew in India fulfilled the accepted<sup>20</sup> diagnostic criteria for CAD, based on reproducible ECG evidence of exercise-induced myocardial ischaemia. 8 of them underwent CA voluntarily. 5 showed normal CA. 3 had obstructive CAD, one of whom had false-negative 201-Thallium Scan. Therefore, the definitive and diagnostic status accorded to Stress-ECG profile, favouring CAD in asymptomatic flying personnel, towards final aeromedical disposal, needs reappraisal.

#### Introduction

Asymptomatic coronary atheroma is commonplace. Actual fatal aircraft accidents due to pilot incapacitation from this cause are very rare; incidents in the air are not, however, uncommon.<sup>10</sup> Therefore, one important objective of cardiovascular (CV) evaluation of aircrew is to detect Coronary Heart Disease (CAD) at the very early latent stage.

Development of obstructive CAD, demonstrable as reproducible ECG features of exercise-induced myocardial ischaemia, at present precludes medical clearance for flying duties.<sup>9,18</sup> This has led to Stress-ECG occupying a definitive status in the diagnosis of Asymptomatic Ischaemic Heart Disease (Asy IHD) and the basis for final aeromedical disposal.

In the clinical setting, using present treadmill technique and diagnostic criteria, Stress-ECG is reported to be 60% to 64% sensitive and 89% to 93% specific for CAD.<sup>19</sup> However, considerable work<sup>2, 4, 6, 10, 17, 18, 23</sup> point to the limitations of this

procedure in concluding the existence of occult CAD in asymptomatic individuals.

The predictive value of Stress-ECG for occult CAD amongst asymptomatic, otherwise clinically normal men, is found to be only about 40% at best, if Coronary Arteriogram (CA)<sup>24</sup> or cardiac events are endpoints. We are concerned in the main with the unacceptably high proportion of 'Stress Test False Positive' results indicated. Repercussions on the individual and the organisation, of labelling an asymptomatic and active aircrew, as harbouring CAD, based on eventually a False Positive Stress-ECG, need no elaboration. In the event, possibility of medical profession alienating aircrew and thus, destroying the main safety factor of mutual confidence, cannot be ignored.

Therefore, such 'Stress-Test Positive' cases need another follow-up investigation of proven sensitivity and specificity approaching unity and applicable to this population. Wall motion/ejection fraction abnormalities by Ultrasound and Radionuclide Ventriculogram (RNV) and prevalent perfusion studies by Thallium-201 (201 Th Scan), though having higher predictive value than exercise electrocardiography<sup>14</sup>, lack the 'gold standard' of CA. Further, from the standpoint of utmost flight safety, which cannot be compromised, the emphasis now squarely also shifts on to sensitivity of the follow-up procedure, so that no more 'False Negatives' are encountered whilst screening the 'Stress Test False Positives'.

Presently, aeromedical assessment does not enforce, as a routine follow-up, further investigative procedures on 'Stress Test Positives' prior to finalisation of their flying status. The invasive study, CA, remains voluntary under individuals' own arrangements. Authenticated results of the examination, though when made available, are taken into reckoning by Aviation Medical Examiners.

During the course of cardiovascular evaluation in India of Air Force Aircrew and Civil Flight Crew, few of the 'Stress Test Positives' cases opted on their own for further investigative procedures, including CA, at home and abroad, and were reassessed. A review of ECG diagnosis of Asy IHD was undertaken by us on the basis of these cases.

#### Material and Methods

ECG reports contained in the medical dossiers of 3339 Air Force Aircrew (Officers) and 2354 Civil Flight Crew (Total No. 5693), irrespective of their

current flying status, were surveyed. The period covered was 15 years between 1968 and 1983. Those carrying any cardiac diagnosis were screened for Myocardial Infarction (MI)/Acute Coronary Insufficiency (ACI)/Angina Pectoris (AP)/Asymptomatic Ischaemic Heart Disease (Asy IHD)/ECG Abnormality (ECG Abn). Out of them, individuals either asymptomatic or presented with non-cardiac symptoms, but subjected to Cardiovascular Stress Testing, were further examined and Asy IHD cases segregated. Clinical notes of these individuals were scrutinised in detail for confirmation of (a) cardiac symptom-free status, (b) absent cardiac events, (c) evidence of significant, reproducible S-T segment depression on Stress-ECG, (d) any follow-up investigative procedures undergone and (e) final aeromedical disposal, either permanent grounding or impending prospects of the same, solely based on Stress-ECG features. It is noted that ECGs are reported in adequate detail in the individual Medical Case Sheets and Medical Board proceedings. Whenever documentary reports warranted check and clarification, original tracings/reports were studied. From them qualifying all the above criteria, fulfilling ECG diagnosis of Asy IHD for the purpose of this survey, individual cases, who were studied by CA, were compiled and contributed the material for this paper.

#### Results

Table - 1 reveals that, presently, 72 totally asymptomatic, clinically otherwise normal and active Air Force and Civil Flight Crew, fulfill the accepted<sup>20</sup> diagnostic criteria for CAD, based on persisting reproducible ECG evidence of exercise-induced myocardial ischaemia.

Table - 1  
Number of Air Force Aircrew (Officers)  
and civil flight crew with Cardiac  
Diagnosis of Asy IHD based on ECG

	Air Force	Civil	Total
A. Stress test positive	33	39	72
B. CA Undergone (Mean Age - 38 yr)	2	6	8
C. Coronaries fully Patent	2	3	5
D. Fixed obstructive CAD (Any Degree)	0	3*	3*

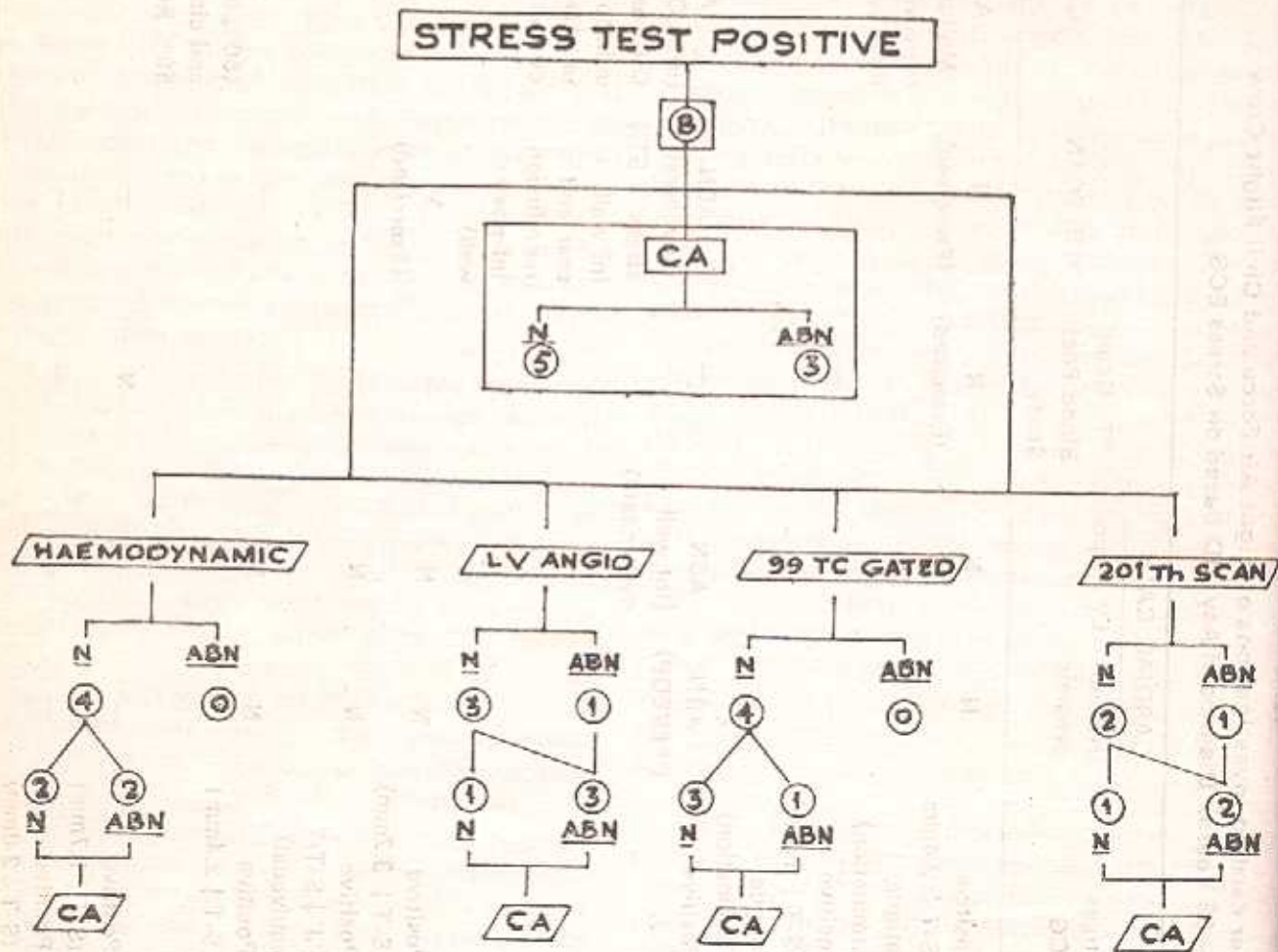
\*<sup>201</sup>Th Scan Normal in one case

Table - II  
 Salient findings on further cardiac investigations of Eight Air Force and Civil Flight Crew  
 (Mean Age—38 Years) Diagnosed Asy IHD based on Stress ECG

No. Case Index	AF/ Civil	Age (Yr)	Hours Flown	Stress ECG	CARDIAC CATH			<sup>201</sup> Th SCAN	<sup>99</sup> Tc Gated Blood Pool Study	CA
					Haemo- dynamic	LV Angio				
1. KCS	Civil	45	17200	Positive (S-T ↓ 2.4mm Fatigue termination)	N	N	N	(Exercised)	N	ABN (Multiple 25% narrowing in all three vessels)
2. VKK	"	36	7660	Positive (S-T ↓ 1.7mm Fatigue Termination)	—	—	—	—	—	N
3. HCS	"	44	7150	Positive (↑ LVEDP)	ABN (↑ LVEDP)	ABN (Inf wall dyskinesia)	—	—	ABN (Low level stress ∴ ST ↓ Inf wall scar and reperfusion inf-poster wall)	ABN (RCA Occluded Diffuse disease mild to severe in LAD and circumflex)
4. RK	"	41	9330	Positive (S-T ↓ 3.2mm)	N	N	—	—	N	N
5. NGJ	"	23	Nil (Initial)	Positive ('J' ↓ S-T/T equivocal)	N	N	—	—	—	N
6. SB	"	48	11350	Positive (S-T ↓ 2.4mm)	N	N	—	—	—	ABN (50% obs LAD and circumflex & 50% RCA)
7. PSK	AF	37	3250	Positive (S-T ↓ 1.7mm)	—	—	N	—	—	N
8. MBS	AF	31	2485	Positive (S-T ↓ 2.0mm)	—	—	—	—	—	N

Table III

Interrelated findings on further Investigations (RNV, 201-Th, Haemodynamic, LV ANGIO & CA) of Eight Stress Test Positive Cases



8/72 of these Asy IHD cases (Mean Age 38-Yr) volunteered on own arrangements to undergo further investigations, including CA. Only one of the three cases revealing angiographically fixed obstructive CAD, showed haemodynamic ( $\uparrow$  LVEDP) and LV Angio (Infr wall dyskinesia) abnormalities. One of the two cases with abnormal CA, who concurrently underwent RNV, had normal findings. In one of the two cases who had angiographically 25% multiple narrowing in all the three vessels Stress <sup>201</sup>Th Scan was normal (Tables 2 & 3).

One or more cardioactive drugs for IHD had been exhibited on a long term basis, prior to CA, in three out of the five cases encountered with angiographically normal coronary arteries.

#### Discussion

Survey of 5693 ECGs for the 15 years period 1968-83, revealed that (Table-1) 72 asymptomatic Air Force and Civil Flight Crew in India are Stress-ECG positive and diagnosed as having CAD (Asy IHD). As a result, their final aeromedical disposal has been grounding or impending prospects of the same.

UHL and FROELISCHER<sup>24</sup> have summarised the work on maximal or near-maximal Exercise Testing with Coronary Angiography and comparatively studied in asymptomatic apparently healthy men, the prevalence of angiographically demonstrable CAD with Exercise Test induced ECG S-T Segment

depression. It is found that the predictive value of stress testing in this group of population is at best 40% only. 5 out of 8 Stress-Test Positive cases (Mean Age-38 years) reviewed also here (Table-1) had no demonstrable CAD on CA. This is seen in sharp contrast to the reported 89% to 93% specificity of Stress-ECG amongst general patients population.

The predictive value of Stress-ECG would depend upon CAD prevalence in the Test Group (Baye's Theorem<sup>19</sup>). Personnel employed on active flying duties comprise a distinctive subset of population. They are (a) rigidly preselected for medical fitness, (b) younger in average age, (c) asymptomatic, (d) clinically normal and (e) generally devoid of significant Coronary Risk Factors. These attributes qualify for low CAD prevalence as borne out below. Chandigarh Survey<sup>3</sup> of urban population had pointed to a prevalence of "probable" CAD (Criteria of Epstein et al) in 66/1000 males above 30 years. On a similar basis, however, CAD prevalence rate is 16 per 1000 (150/9420) amongst all Air Force Officers<sup>5</sup>. When the scope of diagnosis was enlarged to include Stress-ECGs also, the prevalence rate rose only to 25 per 1000 (280/9420 cases).

Thus, Stress-ECG is seen to be of unacceptably low specificity as a diagnostic test for Asy IHD amongst aircrew. Since High False-Positive rate is indicated in low disease prevalence group<sup>3,19</sup> its current decisive basis for final disposal of flying status would appear unjustified.

In this situation, immediate and unequivocal conviction, not only whether CAD exists, but also equally unequivocally the opposite, is warranted with recourse to another follow-up investigative procedure. Ideally, such procedure should be (a) a non-invasive technique, (b) of proven high sensitivity in Asymptomatic Stress-Test Positive, besides being highly specific for CAD, so that (c) any False Negatives do not undermine utmost interests of flight safety. Ultrasound and Radionuclide Cardiac Imaging require to be considered rigidly within the above framework.

Echocardiography and RNV, which are non-invasive, permit detection of CAD indirectly by assessing global or regional abnormalities of ventricular wall motion and ejection fraction, under rest and after exercise. Thallium-201 Scan is more direct a measure, imaging myocardial haemoperfusion. It is

to be borne in mind that, a minimal, subcritical, subclinical stage could be envisaged in the spectrum of evolving CAD, wherein LV function may not yet be recognisably compromised in these terms and yet the onset of disease process is not commensurate with flying task requirements. Echocardiographic diagnosis of CAD carries high specificity, but suffers from poor sensitivity, though it is possible to attain higher sensitivity for detecting severe Left Main disease with Cross-Sectional Echocardiography<sup>18</sup>. Presently reported sensitivity of 0.82 for both Exercise Radionuclide Cineangiography (RNV) and Exercise Thallium-201 Imaging<sup>15,21</sup>, bears serious reservation of differing population basis (heterogeneous patients population). Exercise Radionuclide Angiography yielded a sensitivity of 85% for global and 62% for regional abnormalities when compared with Thallium Perfusion in a study of 32 asymptomatic men<sup>23</sup>. STOLZENBERG et al<sup>21</sup> studied 53 patients with Stress Thallium Scan and CA and reported 0.83 sensitivity for Stress Thallium Scan in detecting CAD lesions of 70% or more. However, there were 5 False-Negative Scans even at this level of significant lesions, which is disturbing. UHL et al<sup>22</sup> classified 191 asymptomatic airmen according to Coronary Arteriography findings (Normal, <50% and >50% obstruction) and compared with 201-Th Scintigram, both unprocessed and processed by computer enhancement. For any degree of angiographically demonstrable fixed obstructive CAD, unprocessed Scintigram yielded a sensitivity of 0.59, though very highly specific (0.98). On the other hand, computer enhancement of the Scintigram realised the sensitivity index of 0.88. An unprocessed negative 201 Th Scintigram can prove fallacious in the presence of minimal disease.

Therefore, till such time the Computer-Enhanced Exercise Thallium-201 Scintigraphy is proven in large scale compatible asymptomatic population studies, it follows that CA is a selective occupational indication for cases manifesting positive Stress Test and Negative Radionuclide Imaging in aerospace cardiology. In fact, this might lead to a reappraisal of the existing policy to permit flying in such instances. In United States Air Force, 12 aviators, with no single lesion greater than 30% and aggregate lesion not greater than 50%, were returned to flying status under medical surveillance, including follow-up invasive study.<sup>11</sup>

While reapproaching the diagnosis of Asy IHD

based on positive Stress-Test, the following would still need reckoning: (a) CAD with Angiographically Normal Coronary Arteries, which may have aetiological and prognostic implications different from fixed obstruction?; approximately two-thirds of patients with significant CAD documented by Coronary Angiography have a positive Exercise ECG and a positive Exercise ECG in a normal person has also been shown to correlate with the subsequent development of significant CAD.<sup>5</sup>

### Conclusion

The role of Stress ECG as a SCREENING TEST for detection of Asy IHD amongst flying personnel remains invaluable. However, it is seen not DIAGNOSTIC in this group to form the decisive basis for final disposal of flying status. Such Stress Test Positive individuals need to be subjected to Radionuclide Cardiac Imaging to corroborate existence of CAD. In such instances, where Stress-Test is positive but Radionuclide Imaging is negative, CA is a selective indication as a prerequisite for eventual aeromedical disposal of aircrew.

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