

# Ambulatory Monitoring in Evaluation of Aircrew with Cardiovascular Problems

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## Abstract

SIXTY two aircrew with cardiovascular problems have been evaluated with stress tests and various other non-invasive tests and then subjected to 24 hour ambulatory monitoring. Ten cases had proved and stabilised old myocardial infarction, 12 were suspected cases of ischaemic heart diseases, 20 cases had asymptomatic nonspecific ECG abnormality and 20 cases had various cardiac arrhythmias. Thus 52 cases were diagnostic problems. Nineteen (36.53%) of these 52 cases could be confirmed to have ischaemic heart disease by ambulatory monitoring in contrast to 10 cases (19.23%) who could be so diagnosed by combined stress tests and other non-invasive tests. Eleven cases (55%) out of 20 were found to show deterioration of arrhythmia by ambulatory monitoring requiring institution of therapy. Thus ambulatory monitoring is found to be useful in diagnosis and disposal of aircrew with cardiovascular problems over and above the stress tests and other non-invasive tests done by us.

## Introduction

Evaluation of ECG abnormality in aircrew has dual significance: (1) to detect organic cardiac disease at the earliest in cadets and young pilots, so that they can be withdrawn from flying for flight safety and (2) to rule out significant cardiac disorder in experienced pilots so that they can continue their flying career to the best interest of the state. With these ends in view, we evaluate the aircrew with a battery of stress tests and non-invasive tests at Army Hospital, Delhi Cantt. Twenty four hour ambulatory monitoring has been recently employed

by us in evaluation of cardiovascular problems in aircrew in addition to other tests and we present our experience here.

## Material and Methods

Aircrew included in this study were referred to Chief Consultant in Medicine for evaluation of their cardiovascular problems. They were subjected to detailed clinical evaluation and relevant biochemical and radiological investigations at Army Hospital, Delhi Cantt. Resting 14 lead ECG was recorded which was compared with the available old graphs. Cases without any complications were then subjected to stress tests including Master's double two step exercise and multistage graded treadmill exercise. All cases with proved ischaemic heart disease were subjected to submaximal exercise (85% of the age predicted maximal heart rate) whereas others were given maximal exercise<sup>1</sup>. Investigations like trans-thoracic electrical impedance, systolic time interval and echo-cardiography were done wherever indicated. Twenty-four hour ambulatory monitoring was done in all those cases where the diagnosis remained uncertain despite the various non-invasive tests mentioned above.

For recording of ambulatory monitoring, disposable pre-jelled electrodes were applied at the CM5 position<sup>2</sup> after appropriate cleaning of the site of electrode application (Figure 1). A low weight portable Cardiodyne Cardiocassette tape recorder which could be carried easily was used in majority of cases. Some cases were also subjected

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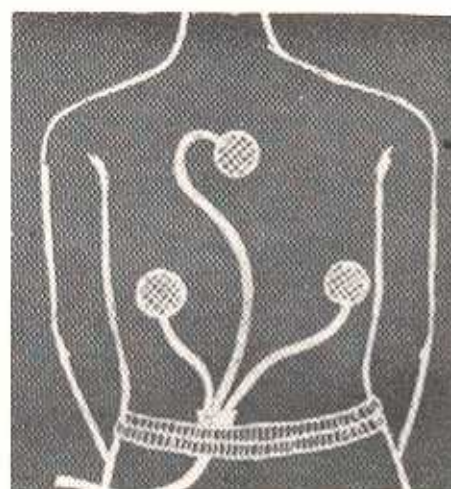


Fig. 1

Diagrammatic representation of the electrode application during ambulatory monitoring. In CM5 recording, the positive electrode is applied on the left 5th intercostal space on the anterior axillary line (LV5 position) and the negative electrode is applied on manubrium sterni. The neutral electrode for earthing (E) is placed at RV5 position.

to ambulatory recording with Oxford Medilog system which has facility of continuous recording for 24 hours<sup>6</sup>. Patients were advised to maintain a chart where important activities or significant symptomatology were recorded against time of occurrence. They were reviewed after 24 hours when the tape recorder was disconnected and the cassette was subjected to analysis. The Cardiodyne Cardio-cassette was played back into an online ST segment and heart rate computer (Avionics-2900). The cassettes of Oxford Medilog were played back into its computer with facility for quick analysis (within 30 minutes) of ST segment displacement, ectopic count and heart rate variations in the 24 hour record. Some of the cases were subjected to repeat 24 hour period of ambulatory monitoring for arriving at correct conclusion. The ECG abnormalities were compared with the symptom and event chart. Permanent records were obtained of ECG changes for further reference.

ST segment displacement was the main criterion for positivity during stress tests<sup>7</sup>: horizontal or downsloping ST depression of 0.5 mm or more for at least 0.08 seconds was considered positive for Master's double two step exercise. Horizontal or downsloping depression of 1.0 mm or more, slow upsloping ST depression of 1.5 mm or more and ST

elevation of 1.0 mm or more were considered positive for treadmill exercise. ST segment measurements were done by the computer at a point 65 milliseconds after the end of preceding R wave. J depression or T inversion noted in isolation during the treadmill exercises were not considered 'ischaemic' by us, but were followed up further to evaluate them in totality.

#### Observations

Sixty two aircrew were included in this study. Ten were proved cases of old stabilised myocardial infarction (included as controls) and 52 cases had diagnostic problems. Their age varied between 26 and 45 years (Table I). The subjects were divided

TABLE I

#### Diagnosis and age distribution

Group	Diagnosis	Number	Mean age (Yrs)	Patient-hours of ambulatory monitoring
A	1 Old stabilised MI	10	36.84	334
	2 Suspected IHD	12	33.81	408
	3 Nonspecific ECG abnormality	20	31.32	576
B	1 Sinus Bradycardia	4	38.21	144
	2 W.P.W. Syndrome	3	29.84	96
	3 Extrasystoles SVPB-5 VPB-8	13	33.54	408
Total		62	33.53	2016

into two groups. Group 'A' consisted of 42 cases—10 cases had proved and old stabilised myocardial infarction (controls), 12 had either clinically or electrocardiographically suspected ischaemic heart disease (IHD) and 20 cases had non-specific asymptomatic ECG abnormality (Table II). Group 'B' consisted of 20 cases, 4 cases had persistent sinus bradycardia, 3 cases had Wolff-Parkinson-White syndrome and 13 cases had multiple supra ventricular (5 cases) and ventricular (8 cases) premature beats. Clinical evaluation in all did not reveal any cardiovascular complications. Relevant biochemical and radiological parameters were normal. Abnormalities recorded during the treadmill exercise and 24 hour ambulatory monitoring are discussed under the respective heads.

TABLE II

Evaluation of cases with IHD

Sl No	Diagnosis	Number of cases	Positivity by			
			Treadmill		Ambulatory monitoring	
			Ischaemic ST depression	Arrhythmia	Ischaemic ST depression	Arrhythmia
1.	Old stabilised MI	10	5(50%)	3(30%)	8(80%)	5(50%)
2.	Suspected IHD	12	3(25%)	1(8.3%)	7(58.3%)	2(16.7%)
3.	Nonspecific ECG abnormality	20	3(15%)	...	5(25%)	1(5%)
TOTAL		42	11(26.2%)	4(9.5%)	20(47.6%)	8(19%)

**Group A****1. Old stabilised myocardial infarction (MI):**

Five (50%) cases out of 10 with proved and stabilised MI showed positivity during treadmill exercise. They were subjected to 384 patient-hours of ambulatory monitoring and during the analysis of the taped ECG 8 cases (80%) showed ischaemic ST depression during periods of stress and strain. Rhythm analysis showed 7 cases had sinus tachycardia of varying degree, 3 had ventricular premature beats, 1 case showed supra ventricular tachycardia and 2 cases had ventricular tachycardias of paroxysmal nature during stressful periods of recording.

**2. Suspected cases of ischaemic heart disease (IHD):** Twelve cases had either atypical angina pectoris or unequivocal ECG abnormalities suggestive of ischaemia. Three cases (25%) out of the 12 showed positivity during maximal treadmill exercise whereas 7 cases (58.33%) showed positive evidence of IHD during ambulatory monitoring (Figure 2). Rhythm analysis in these cases showed only infrequent ectopics in 2 cases.

**3. Asymptomatic non-specific ECG abnormality:**

Twenty aircrew had no complaints, but their ECG either at rest or after Master's double two step exercise was found to have non-specific ST-T changes. These ECGs were recorded as service requirements. Three cases (15%) out of 20 showed positivity during maximal treadmill exercise whereas 5 cases (25%) showed positivity during stressful periods of ambulatory monitoring. Rhythm analysis of the ambulatory records of one (5%) case showed supra-ventricular premature beats.

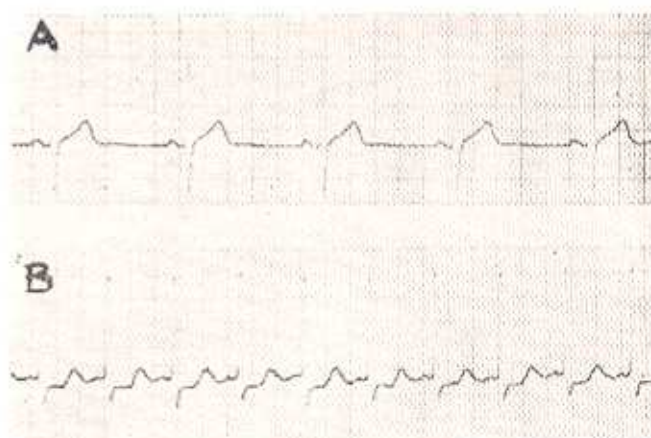


Fig. 2

CM5 recording (B) shows ST depression of 2.5 mm during an episode of transient retrosternal discomfort in the afternoon. Record (A) shows normal sinus rhythm recorded at the time of application of ambulatory monitoring.

**Group B**

**1. Sinus Bradycardia:** Four cases showed persistent sinus bradycardia—rate varying between 45 and 60/min, without any electrocardiographic evidence of A-V block at any time. Only one case (25%) showed evidence of ischaemic heart disease during maximal treadmill exercise as well as during 24 hour ambulatory monitoring. Rhythm analysis of them showed two cases reverting to sinus tachycardia during an attack of palpitation and the other two cases had varying degrees of sinoatrial block (Figure 3).

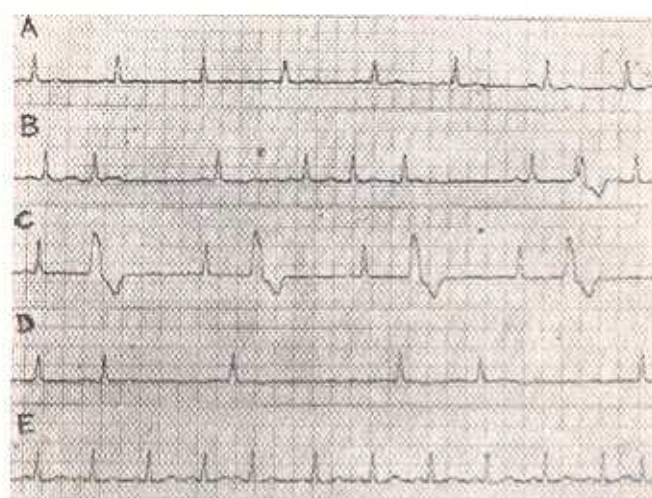


Fig. 3

CMS recording of a patient shows Bigemini rhythm (C), periods of sinoatrial block (B and D) and sinus tachycardia (E) at various periods of activity and symptomatology during the 24 hour ambulatory monitoring.

2. *Wolff-Parkinson-White Syndrome*: Three cases had typical electrocardiographic evidence of W.P.W. syndrome without any clinical symptoms. No evidence of IHD was detected in them either by maximal treadmill exercise or by 24 hour ambulatory monitoring. Review of tape recordings for rhythm disturbances revealed evidence of short paroxysmal supraventricular tachycardias in two cases.

3. *Extrasystoles*: Thirteen cases had evidence of multiple extrasystoles during ECG recording. Five cases had supraventricular ectopics and 8 had ventricular premature beats. Three cases (23.07%) out of the 13 showed evidence of IHD in maximal

treadmill exercise whereas 6 cases (46.15%) had evidence of IHD in 24 hour ambulatory monitoring (Table III). Rhythm analysis showed frequent runs of sinus tachycardia with disappearance of ectopics in 6 cases but increase in frequency in the rest. Four cases showed runs of paroxysmal supraventricular tachycardia and 2 showed ventricular tachycardia in short outburst.

### Discussion

ECG recordings at rest or after various stress tests are not as informative or diagnostic as those recorded during an attack of chest pain, palpitation, or giddiness. The routine ECG recorded in the clinics encompasses a very short period of the day and can not be representative of all that happens to a person's cardiovascular system during whole day's stress and strain. The various activities of day to day life like work, play, meals, attending to toilets, reading, relaxation, smoking, drinking or sleep can never be duplicated at the clinician's room. These activities may precipitate a 'heart attack' and by the time an ECG is recorded following the episode either at the patient's own place or in the clinic, much time and hence diagnostic information is lost. This fact ultimately led to the development of 24-hour electrocardiographic recording equipment by Holter<sup>9</sup> in 1961. By this technique as much as 2,50,000 heart beats are recorded and analysed in contrast to only 40 to 80 beats recorded during a 12-lead ECG recording in the clinics. This technique has been found to be very useful in follow up of cases with acute myocardial infarction, in diagnosis of patients with typical chest pain or with typical angina but normal ECG recorded in the

TABLE III  
Evaluation of cases of arrhythmia

Sl No	Diagnosis	Number of cases	Positivity by			
			Treadmill		Ambulatory Monitoring	
			IHD	Deterioration of arrhythmia	IHD	Deterioration of arrhythmia
1.	Sinus bradycardia	4	1(25%)	1(25%)	1(25%)	2(50%)
2.	WPW Syndrome	3	0	0	0	2(66.7%)
3.	Extrasystole	13	3(23%)	4(30.8%)	6(46.2%)	7(53.8%)
TOTAL		20	4(20%)	5(25%)	7(35%)	11(55%)

clinics<sup>13,14,16</sup>. Study of arrhythmias of known aetiology can also be very rewarding as sufficient and extensive electrocardiogram recorded during the 24 hour period will enable the cardiologist to study the aetiology, origin, nature, course and termination of these arrhythmias, arrive at concrete diagnosis and be able to treat adequately. A group of cases with frequent attacks of palpitation, giddiness or syncopal attacks with cardiac aetiology are often helped by this technique and saved from exhaustive investigations by the cardiologists, internists, neurologists and psychiatrists<sup>2,4-6,13,15,17,19</sup>.

The cardiovascular problems in aircrews, which have serious implications for obvious reasons have been evaluated by various noninvasive techniques including maximal treadmill exercise, systolic time interval studies, transthoracic electrical impedance, echocardiography, hypoxia, +Gz stress and other simulated flying stresses. Telemetry recording and even ambulatory monitoring recording during actual flight have also been tried<sup>16,20</sup>. Evaluations with ambulatory monitoring on the ground in addition to the above tests have added advantage. The pilot is subjected to prolonged periods of ambulatory monitoring during which he leads his normal day to day life. ECG abnormalities or rhythm disturbances, if any, are evaluated under the stress and strain of day to day living, exertions, relaxation, smoking, drinking or sleep and provide informations in relation to symptomatology or activities, thus either leading to a conclusive diagnosis of organic heart disease or excluding it altogether.

Some reports have been published on ambulatory monitoring on normal healthy pilots during actual flight showing occurrence of sinus tachycardia and infrequent extrasystoles<sup>20</sup>; but none are available on abnormal aircrew in flight. It is likely to expose a pilot with abnormal ECG or ischaemic heart disease to such an inflight evaluation.

We have studied 62 aircrew with cardiovascular problems with 24 hour ambulatory monitoring. Among the group with proved and stabilised IHD, 80% showed positivity by this technique in contrast to 50% by other non-invasive methods including stress tests. Patients with suspicion of IHD showed positive evidence of IHD in 58.33% cases by the ambulatory monitoring, in contrast to 25% positivity recorded by various stress tests. Kishida et al<sup>12</sup> have shown even 84.2% positivity in their group of

cases suspected to have IHD. 50% of our cases with ischaemic heart disease showed various arrhythmias by ambulatory monitoring, inconsistent with various reports showing 42 to 72% of arrhythmia in IHD when subjected to ambulatory monitoring<sup>11,16</sup>.

Among the cases with various arrhythmia, 35% (in contrast to 20% positivity by treadmill exercise) showed evidence of IHD by ambulatory monitoring. A still larger number (55%) showed deterioration of the arrhythmias leading to conclusive diagnosis. One out of 4 with sinus bradycardia was detected to have IHD by both stress tests and ambulatory monitoring, whereas 2 cases showed evidence of sick sinus syndrome during the period of ambulatory monitoring. None of the cases with W.P.W. syndrome showed evidence of IHD by either stress tests or ambulatory monitoring. Two cases, however, showed infrequent runs of supra ventricular tachycardia during ambulatory monitoring; though much less an incidence of supra ventricular tachycardia in W.P.W. syndrome than reported in literature<sup>11</sup>, it justifies the use of ambulatory monitoring in evaluation of W.P.W. syndrome.

Extrasystoles are recorded quite frequently during ECG recordings in clinics. It is well known that ectopies may occur due to non-ischaemic and extra cardiac causes, prominent among them being worry, anxiety and apprehension prior to facing a medical test during annual medical or promotion medical board examinations. Ambulatory monitoring in our series revealed confirmatory diagnosis of IHD in 6 cases (46.15%) and deterioration of arrhythmia in 7 cases (53.89%). Six cases (46.16%) showed disappearance of the ectopic beats during runs of sinus tachycardia under stress and strain, ruling out the possibility of organic heart disease.

Thus a total of 23 out of 52 (44.23%) were provided with conclusive diagnosis and disposal ending the uncertainty in them, whereas 29 cases (55.76%) were cleared from the suspicion of organic heart disease. This is in contrast to 10 (19.23%) cases who could be conclusively diagnosed to have IHD by the treadmill exercise and other non-invasive tests.

### Conclusion

Thus ambulatory monitoring is found to be useful and handy in evaluation of cases with cardiovascular problems among aircrew for better diagnosis and

disposal. It is recommended that this procedure of evaluation be used more frequently in evaluation of aircrew with undiagnosed cardiovascular problems before final disposal.

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