Original Article

Ventricular premature contractions and heart rate changes coincident with +Gz induced loss of consciousness

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High-G training has become a necessity in the air forces with the introduction of Air Superiority Fighters. Practice in procedures to combat High-G forces can be safely done in a human centrifuge. During the training, it is equally important to monitor physiological parameters. ECG monitoring is a must as High-G training is known to provoke dysrrhythmias in many subjects. Of these dysrrhythmias, ventricular premature contractions (VPCs) are common. Also during the High-G runs, the subject may go into +Gz-induced loss of consiciousness (G-LOC) inadvertently. Reports of dysbythmias occurring coincident with G-LOC are infrequent. A case of VPCs and Heart Rate (HR) changes coincident with G-LOC, occurring during a Simulated Aerial Combat Maneuver (SACM) is reported.

Keywords: +Gz, cardiac dysrrhythmias, G-LOC, aircrew training

High-G training for aircrew has come to stay in Air Forces with the introduction of Air Superiority Fighters. The thrust of the training is to impart awareness and training in procedures to combat High-G forces. Practice of such procedures can be safely done on the ground using a simulator, ie the Human Centrifuge. The High-G training programme at the Department of Acceleration Physiology, IAM IAF, follows a prescribed format already described by Malik et al in 1991 [1]. During the 4G/8G Simulated Aerial Combat Maneuver (SACM) run, consisting of alternating levels of +4G-15 seconds and +8G-10 seconds, the aircrew is protected against G-forces by the Anti-G Suit (AGS) as well as the Anti-G Straining Maneuver (AGSM). On line video, audio-communication, peripheral light loss (PLL) of 56-60°, blood flow measurement through the superficial temporal artery using a Doppler and Electrocardiographic (ECG) monitoring and recording are done. The run is terminated if the aircrew complain of fatigue, if PLL (peripheral light loss) occurs, if significant dysrhythmias occur or if inadvertent G-LOC (+Gz - Induced Loss of Consciousness) occurs.

ECG changes during acceleration stress have been reported by many investigators and several authors [2, 3, 4] have reported the occurrence of dysrhythmias during centrifuge training. Reports of dysrhythmias coincident with G-LOC are infrequently reported [5,6]. A case of ventricular premature contractions and heart rate changes

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coincident with G-LOC, occurring during a 4G-8G SACM run is described.

Case Report

A 27 year old fighter pilot reported for High-G training after a medical examination. The day prior to the SACM run he successfully completed the ROR (1G/s) High-G runs of +7G-15s, 8G-10s and 9G-5s. On the day of his 4G-8G SACM run, his basal cardiovascular parameters were found to be normal. He was wearing a standard 5-bladder, cutaway type AGS (PPK-1) and ECG recording was done using a CM5 lead configuration and the Digital Acquisition and Retrieval Equipment (DARE), a portable system which the pilot straps on before entering the Human centrifuge gondola. Following a warm-up run, done to test the adequate inflation of the AGS, he began the 4G-8G SACM run. 8.5s after reaching the 5th 8G peak, the subject suddenly went into G-LOC. The run was aborted immediately and the aircrew brought down to 1G. The Absolute Incapacitation Time [7] was 8s. When asked "what happened?" he said he had gone into "G-LOC". He was examined clinically and on completion of the training was routed back to his Unit without a change in his Medical Category.

The medical observer watching the on-line ECG had noticed four isolated VPCs occurring at the 4G and 8G levels just prior to the G-LOC episode. As VPCs are known to occur in High-G runs there was no requirement to terminate the SACM run because of the VPCs.

Observations

The DARE allows for replay of the whole episode on a computer for off-line analysis. The values for the Heart Rate (HR) and G-stress are shown beat to beat. Software allows for zoom and a more detailed analysis, as required. On the replay it was found that:

(a) There were four isolated VPCs occurring 10s, 26s, 36s and 45s prior to G-LOC.

(b) Heart rate changes at comparable 4G and 8G levels were seen and are shown in Table 1 and Figure-1.

(c) 5s prior to G-LOC the HR had started to drop from 151 beats per minute (bpm) to 132 bpm and at or close to G-LOC reached a value of 96 bpm as in Figure 2.

(d) At G-LOC, there was one VPC followed by four sinus beats. The first sinus beat clearly shows a p wave and a normal conduction into the ventricles. In the second beat the p wave is not clear and an abnormal q wave has appeared. The third and fourth beats show normal conduction into the ventricles even though the p wave is not discernable. However, in all these beats the T wave is tall and peaked compared to the earlier T waves. Following these sinus beats another VPC occurred and was then followed by a gradual pick up of the sinus rhythm as the +Gz forces reduced (Fig-2).

(e) 40s after G-LOC a sinus bradycardia suddenly developed (Fig 3).

f. The delta QTc fot the two beats, 1.5 s prior to G-LOC showed a negative value. the values were calculated manually.

Discussion

Ventricular premature contractions are extremely common, even in asymptomatic healthy individuals and have also been found to be more readily provoked by isometric exercise than by dynamic exercise [8]. VPCs are also probably the

commonest dysrhythmia during High-G stress [3, 4]. Higher grades of VPCs as per Lown's Grading [9], if seen, are a cause for termination of the G-stress. However isolated VPCs are seen even in a treadmill test and are considered benign in nature unless they trigger a higher grade of ventricular dysrhythmia. Similarly, VPCs seen in a setting of centrifuge training should also be considered benign as they resolve rapidly on return to 1G. According to Mckenzie, the presence of isolated ectopics could therefore be considered to be a physiological response to the High-G stress and the overwhelming sympathetic response and not due to a pathological process of the heart [4]. However, during the SACM run, fatigue, accumulation of metabolites, increased duration of the G-stress and other factors may play a role in the failure of the compensatory mechanisms ie sympathetic response. Therefore, could the occurrence of the four VPCs, after the aircrew had completed three-8G peaks, be interpreted as a part of the sympathetic response or could it be interpreted as a result of metabolic and electrolyte changes or alteration in the anatomic boundaries of the heart? What, therefore, is the reason for the appearance of two VPCs at G-LOC?

Equally important were the HR changes which occurred as the SACM run progressed. Table 1 and Figure 1 show that at each similar level of 4G and 8G the HR picked up until the fourth

Table 1 : Difference of Heart Rate between comparable levels of 4G and 8G

Levels	Differences in Heart rate in beats/minute (% change) at comparable levels			
	1st & 2nd	2nd & 3rd	3rd & 4th	4th & 5th
4G	37 (33.9)	13 (8.9)	-7 (-4.6)	0 (0)
8G	30 (24.1)	8 (5.19)	-2.5 (-1.5)	-9.5 (-5.9)

Fig 1. Difference in heart rates at comparable levels of 4G and 8G (average heart rate for a particular level is given in brackets)

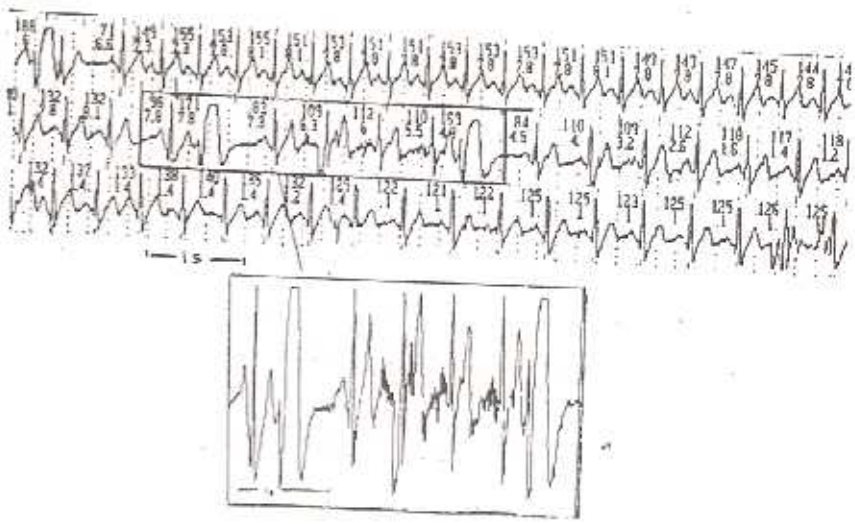
4G and 8G levels, where a slowing down has occurred - could this be due to decompensation? The question is whether the run should have been terminated at this stage? The ECG tracing during on-line monitoring is continuously moving and previous tracings with HR values cannot be recalled on the same monitor. Therefore termination of the run based on comparison of HR values while doing on-line monitoring is currently not possible, but may become relevant. However, what may be relevant for the SACM run may not be so for the ROR (1G/s) High-G runs of 7G, 8G and 9G.

The beat to beat variation, just prior to G-LOC has been shown in Figure 2. This clearly shows a reduction in the HR seconds before G-LOC occurred. At G-LOC, a drop of almost 42 of the HR occurred, i.e. 96 bpm at G-LC compared to 155-164 bpm at other 8G level Following this drop, the heart has recovered ar the dysrhythmia as already described occurre

Table 2: R-R, Q-T, QTc and DQTc Intervals (I seconds) at different stages during the 4G-8G SACM run

Stage of recording	RR	QT	QTc	QTc
10s before start	.75	.35	.406	-
1st 4G level	.437	.28	.424	+18
4th 8G peak	.40	.26	.415	+9
5.5s before G-LOC	.412	.26	.428	+26
1.5s before G-LOC	.475	.275	.399	-7
14s after G-LOC	.512	.275	.384	-22

Fig 2. Continous CM, Recording for 27s alongwith HR (upper values) and 'G' values (lower figures) 10.5 seconds before G-LOC and during G-LOC. The arrow mark indicates when G-LOC occured (see text for explanation) Inset shows the 'zoom' of the early G-LOC period



The sinus bradycardia that developed 40 s after G-LOC has been described earlier by others [2,3,4], and is therefore not dealt with. Another factor worth noting was the changes that occurred in the QTc i.e., the DQTc difference between the beginning of the run and the QTc as the run progressed. As shown in Table 2 the DQTc reached a negative value 1.5 s prior to G-LOC. These changes may indicate a reversal from sympathetic to a parasympathetic response.

Conclusion

We have reported one episode of G-LOC during which there were coincident VPCs and HR changes. Though VPCs are considered benign, when occurring in lower grades and isolated, could they have contributed to the HR changes preceding G-LOC? Are the VPCs which occurred coincident with G-LOC, a sign of the decompensated heart or the recovering heart? Did the HR changes which occurred at least 20-25 s prior to G-LOC mean a failure of the heart to compensate or a beginning of the cardio-inhibition of a Vaso-Vagal attack? Is the Heart Rate Variability (HRV) in +Gz stress important? The answers to these questions, on G-LOC, can only be addressed by further research into the changes occurring in the ECG and other physiological parameters.

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