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Case Report

A case of low G-tolerance: An approach to aeromedical evaluation and disposal

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ABSTRACT

Conventionally, aircrew who is not able to withstand +7 Gz, 15 s with an anti-G suit (AGS) and anti-G straining maneuver (AGSM) is considered to have low G-tolerance. Aircrew suspected to have low G-tolerance needs to be comprehensively evaluated. This paper highlights our approach to aeromedical evaluation and disposal of a suspected case of low G-tolerance in an under-trainee (U/T) fighter aircrew. A 21-year-old U/T fighter aircrew presented with multiple episodes of gray out/blackout while flying syllabus sorties on exposure to 4.5 G and was not able to pull beyond 5 G. A detailed history did not reveal any likely predisposing factors for reducing G-tolerance. A detailed clinical evaluation did not reveal any organic pathology. During high-performance human centrifuge evaluation, his baseline relaxed (R) and straining (S) GOR and rapid onset rate (ROR) tolerance were found to be 3.2 G (R); 6.3 G (S) and 3 G (R); 4.5 G (S), respectively. He was unable to sustain beyond 6 Gz for the 30 s even with AGS and supervised AGSM. He underwent a 12-week supervised physical conditioning program. Reassessment following 12 weeks revealed a significant improvement in physical strength parameters. However, the aircrew could not withstand 6 G for 30 s even with AGS and supervised AGSM. The aircrew was diagnosed as a case of low G-tolerance and was recommended unfit for fighter flying. Any episode of visual symptoms of loss of consciousness due to G forces is potentially incapacitating in the air. Hence, aircrew suspected to have low G-tolerance needs to comprehensively evaluated. The evaluation should include a careful history to rule out any pre-disposing factors and a detailed clinical assessment to exclude organic disability. Aircrew needs to be indoctrinated on correct AGSM technique and proper fitment of AGS must be ensured during centrifuge evaluation. Before labeling an aircrew as a case of low G-tolerance, he should be assessed for his physical fitness and undergo a supervised physical conditioning program.

Keywords: Fighter flying, Low G-tolerance, Blackouts, Centrifuge evaluation, Physical conditioning

INTRODUCTION

Modern fighter aircraft with the capability of hyperagility and maneuverability is capable of sustaining high levels of +Gz acceleration forces.[1] Thus, the aircrew flying high-performance fighter jets should be capable of withstanding the forces of acceleration to protect from its untoward effects which are potentially incapacitating in the air. Poor acceleration tolerance may vary from mild visual symptoms of gray out to G-induced loss of consciousness.[2] Human tolerance to G depends on the value of peak G (G-level) and the duration for which it is applied (G duration). Tolerance criteria for G-level are defined by the ability of a subject to maintain adequate vision and consciousness, whereas, subjective fatigue marks the endpoint of G duration tolerance.[3]

Conventionally, the aircrew who does not successfully complete a rapid onset rate (ROR) run for +7 Gz, 15 s, centrifuge profile with an anti-G suit (AGS), and straining maneuver is considered to have low G-tolerance.[4] Aircrew with lower G-tolerance is more vulnerable to experience symptoms of G stress, namely, grayout, blackout, Almost Loss of Consciousness (A-LOC), and G-induced Loss of Consciousness (G-LOC). The occurrence of such symptoms in the air can lead to acute incapacitation in flight and thus pose a significant risk to flight safety. In addition to low G-tolerance, there are various factors known to reduce G-tolerance in an aircrew.[2] Hence, any incidence of in-flight grayout, blackout, or loss of consciousness must be comprehensively evaluated to ascertain the cause. This paper discusses our approach to evaluating and recommending aeromedical disposal in a case of a fighter under-trainee pilot who developed repeated episodes of in-flight symptoms under relatively lesser G stress.

CASE DETAILS

A 21-year-old under-trainee fighter aircrew reported with multiple episodes of grayout/blackout during Stage-III fighter training. The first incidence occurred in a sortie involving +6 Gz acceleration, wherein, he experienced grayout for 2–3 s after crossing 4.8–4.9 G. This subsided spontaneously after offloading by the instructor without any residual symptoms. The second episode of the blackout was experienced after 5 days of the first incidence while crossing 5 G. The instructor took over the controls soon after the trainee reported visual symptoms. Once the trainee regained clear vision, he was allowed to land safely. The subsequent episodes of grayout/blackout were experienced each time the aircraft reached 4.5–5 Gz as per the data collected from Flight Data Recorder. The case was referred to the Institute of Aerospace Medicine (IAM), Bengaluru, where a comprehensive evaluation was undertaken.

Detailed history revealed that the trainee aircrew was conscious in each of these episodes and having lost only peripheral to central vision with no features suggestive of A-LOC or G-LOC. The trainee aircrew instinctively offloaded the G on experiencing the visual symptoms and informed the instructor. These sorties were flown during the day (pre- and post-noon) and there was no history of any other associated factors that could reduce his G-tolerance. He gave a history of long-distance running during his training days but he was not into the same for the past 1 year. He was a non-smoker and teetotaler and did not give any history suggestive of sleep deprivation/fatigue associated with the incidences.

His hematological, biochemical, and clinical evaluation were within normal limits. His ECG, TMT, 2D-Echo, and head up tilt test did not show any abnormality. Heart rate variability assessment did not reveal any evidence of parasympathetic predominance. The aircrew was indoctrinated on correct Anti-G Straining Maneuver (AGSM) technique and after ensuring a properly fitting AGS, was subjected to centrifuge evaluation in the high-performance human centrifuge (HPHC). The HPHC evaluation revealed that the aircrew had repeated incidences of graying out at 5–5.5 Gz during multiple runs. In spite of no underlying predisposing factors and the aircrew undertaking supervised AGSM, the possibility of poor physical conditioning resulting in low G-tolerance was considered. He was assessed for his physical fitness [Table 1] and was advised to undergo a 12-week physical conditioning program for strength training.

The aircrew was reviewed at IAM after 12 weeks of completing the physical conditioning program. Reassessment of his physical fitness revealed a significant improvement in most of the parameters [Table 1].

The aircrew was subjected repeat HPHC evaluation. His HPHC evaluation performance before and after the physical conditioning program is shown in [Table 2]. The relaxed and straining GOR G-tolerance were found to be 3.4 G and 6.32 G, respectively. Similarly, the relaxed and straining ROR G-tolerance were 3 G and 4.5 G, respectively. There was no significant improvement in the G-tolerance of the aircrew despite demonstrable improvement in physical conditioning. During HPHC evaluation, the aircrew experienced repeated episodes of blackouts on exposure to 7 G despite demonstrating good AGSM technique and correct AGS fitment. The aircrew was subjected to a repeat ophthalmological examination and a fresh psychological evaluation; however, these evaluations were essentially normal. The aircrew was diagnosed as a case of low G-tolerance and was recommended unfit for fighter flying.

DISCUSSION

This case was referred to IAM, Bengaluru, with a history of recurrent in-flight grayout/blackout during Stage III training on Advance Jet Trainer. This is pertinent to note that Advanced Jet Trainer used for the Stage III training can go up to a maximum of 8 G.[5] The aircrew was evaluated as per the existing policy where any transient/episodic loss of consciousness needs to be thoroughly evaluated to rule out organic causes.[6] A thorough clinical evaluation was

Table 1: Assessment of Physical Fitness.

Parameters	Before	After 12 weeks
Bodyweight	71.4 kg	74 kg
1 RM bench press	74.6 kg	93.3 kg
1 RM squat	56 kg	92.8 kg
Push-up	23 reps	38 reps
Free squat	40 reps	40 reps
Curl-up	40 reps	57 reps

Table 2: Centrifuge evaluation.

Profile	Duration	AGS	AGSM	Before	After
GOR	-	No AGS	No AGSM	3.2 G (R) and 6.3 G (S)	3.4 G (R) and 6.3 G (S)
ROR	-	No AGS	No AGSM	3 G (R) and 4.5 G (S)	3 G (R) and 4.5 G (S)
4.5 G TT	60 s	Yes	Yes	Completed	Completed
6 G TT	30 s	Yes	Yes	Blackout-thrice	Completed
7 G TT (done on three different days)	15 s	Yes	Yes	Did not attempt	Sustained for the duration, however, blackout

undertaken in the case in accordance with the existing policy which did not reveal any abnormality.

There are various predisposing factors that affect G-tolerance adversely such as sleep deprivation, alcohol consumption, medication, stress, and flying currency (whether he has been off flying high-G sorties for 7 days or more).[2] A detailed history, thus, assumes significant importance in the evaluation of such cases to rule out any predisposing factors. None of such underlying factors could be identified in our case.

The baseline GOR and ROR tolerances, in our case, were found to be 3.2 G (relaxed); 6.3 G (straining) and 3 G (relaxed); 4.5 G (straining), respectively. This implies that the G-tolerance was lesser with higher onset rates. The aircrew was subjected to high-G runs while wearing an anti-G suit and doing supervised AGSM. Burton reported that AGS along with the anti-G valve offers a 1.5 G improvement in relaxed G-tolerance.[7] An ill-fitting AGS is known to affect G protection.[2,5] Similarly, a properly executed AGSM offers significant G protection to aircrew.[2] Gillingham *et al.* reported that efficient AGSM, consisting of both muscle tensing and respiratory components, could raise G-tolerance by 4 G.[8] Hence, the aircrew should be indoctrinated on correct AGSM procedures and proper fitment of AGS must be ensured before undertaking centrifuge evaluation in such cases. The same was followed in the instant case. Proper fitment of AGS and functioning of the anti-G valve were ensured. The aircrew was indoctrinated with the correct AGSM under supervision at 4.5 G. However, in spite of that, the aircrew experienced repeated episodes of blackout and one episode of G-LOC and could not sustain 6 Gz for 30 s. Since the aircrew could not clear minimum G-level exposure, he was not subjected to a simulated target tracking profile for the assessment of G-duration tolerance. We considered two possibilities with these observations; (a) whether the aircrew could not generate adequate muscle power while performing AGSM or (b) the aircrew was a case of inherent low G-tolerance. Hence, assessment of muscle strength and conditioning was considered necessary.

The baseline parameters of physical strength were assessed and the aircrew was indoctrinated into a physical conditioning program. He was recommended to undergo a supervised physical conditioning program for 12 weeks to strengthen his muscle strength to get a maximum benefit out of AGSM. Reassessment after 12 weeks showed a significant improvement in physical strength parameters [Table 2]. However, during HPHC evaluation up to 6 +Gz, the aircrew continued to have repeated episodes of grayout and blackout, even with well-fitted AGS and properly executed AGSM under supervision. In the absence of any clinical disabilities and factors known to reduce G-tolerance and having regained his muscle strength, the inability to withstand 6 G 30 s left us with the possibility of inherent low G-tolerance in the instant case.

As per the available literature, G-tolerance varies among individuals, ranging from +2.2 Gz to +7.1 Gz. Inter- and intra-individual variation of G-tolerance is known. G-level tolerance also varies based on the rate of build-up of +Gz, being more during gradual onset rate in comparison to ROR.[9] Further, there may a day-to-day variation in G-tolerance due to the presence of factors adversely affecting G-tolerance.[3] NATO STANAG 3827 AMD states that aircrew who does not successfully complete a rapid onset, +7 Gz, 15 s centrifuge profile with an AGS, and a straining maneuver would be considered to have low G-tolerance.[4] Similarly, the Advisory Publication 61/26A by Air Standardization Coordinating Committee states that aircrew unable to pass a 7 G, 15 s rapid onset run while wearing an AGS and performing an AGSM should be considered to have low G-tolerance.[4] Our case fitted into this definition of low G-tolerance. Aircrew with lower G-tolerance is more likely to experience symptoms of G stress in flight than those with higher G-tolerance, and thus, it poses significant aeromedical risk and concerns about safety and effectiveness during flying a high-performance fighter aircraft.[4,2] Hence, considering the risk of flight safety in perspective, we considered the aircrew unfit for fighter aircraft.

CONCLUSION

Aircrew suspected to have low G-tolerance needs to be comprehensively evaluated. The evaluation should include a careful history to rule out any predisposing factors and a

detailed clinical assessment to exclude organic disability. Aircrew needs to be indoctrinated on correct AGSM technique and proper fitment of AGS must be ensured during centrifuge evaluation. Before labeling an aircrew as a case of low G-tolerance, he should be assessed for his physical fitness and undergo a supervised physical conditioning program. A similar approach was followed in the aeromedical evaluation and disposal of our case.

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Declaration of patient consent

Patient's consent not required as patient's identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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