Original Article

Almost loss of consciousness (A-LOC) : A closer look at it's threat in fighter flying

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ABSTRACT

Exposure to +Gz acceleration in aerial combat maneuvers has the potential to induce altered state of awareness, which classically includes a continuum of gray out, black out and G-induced loss of consciousness (G-LOC). In this continuum a relatively new entity known as A-LOC has been identified. It is characterised by deficits in cognitive and motor functions of the pilot, without loss of consciousness. It often occurs with short duration, rapid onset G exposures such as 3-5 seconds at high G as seen in centrifuge studies. The neurocognitive symptoms experienced result in loss of situational awareness (LSA) for several seconds and are similar to the relative incapacitation period of G-LOC, though of shorter duration. Studies evaluating symptoms of A-LOC have revealed similarities with those experienced in spatial disorientation (SD). This paper discusses six episodes of A-LOC that occurred during centrifuge training in fighter pilots at the Institute of Aerospace Medicine, Bangalore. It is felt that comprehension and evaluation of the altered state of awareness consequent to A-LOC may give insight into the psychophysiologic dynamics of a variety of incidents of SD and LSA in flight. Investigations into fighter aircraft accidents suspected to be due to SD and LSA must consider the possibility of A-LOC symptoms contributing to the development and / or reactions of aircrew to SD. Attention of the pilots and the aeromedical community needs to be drawn towards understanding the threat potential of A-LOC in combat flying. Proactive intervention by aviation medicine specialists in combat squadrons through interactive sessions with the aircrew, application of questionnaire studies and analysis of acceleration environment can elicit the frequency and quantum of this G related problem.

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KEY WORDS: G-LOC, A-LOC, SD, LSA, Altered state of awareness

Air combat Maneuvering (ACM) is a complex task requiring maintenance of spatial orientation and high levels of situational awareness (SA) on part of the aircrew. Spatial disorientation (SD) or loss of situational awareness (LSA) can be catastrophic to mission completion and flight safety. The modern generation aircraft equipped with state of the art avionics like Display and Sighting Helmet Systems (DASH), high off the bore sight, air to air missiles and super manuverability have revolutionized the close air combat scenario. These advancements impose greater and novel demands on the cognitive functions of the aircrew and continue to tax the human physiological and psychological limitations. Alterations in the state of awareness or inability to orient oneself spatially not only largely influences the outcome of the close air engagement but also endangers life and aircraft.

Exposure to +Gz acceleration in ACM has the potential to induce altered states of awareness, which classically include symptoms ranging from increase in weight to visual symtpoms of gray out, blackout through to catastrophic G-induced loss of consciousness (G-LOC) [1]. To this continuum of visual symptoms leading to G-LOC has been added another entity called A-LOC [2,3].

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A-LOC is characterized by deficits in cognitive and motor functions of the pilot induced by +Gz acceleration stress without loss of consciousness. It often occurs with short duration, rapid onset G exposure [2, 3]. The neurocognitive symptoms experienced result in LSA for several seconds. US Navy has reported aviators experiencing brief and variable episodes of confusion, amnesia, apathy, LSA, weakness or twitching of the hands during ACM characterised by rapid onset G loads, relatively low G levels of short duration and less than 1G maneuvers [2]. Studies evaluating episodes of A-LOC in human centrifuge have revealed similarities with those experienced in SD. Altered state of awareness consequent to an in-flight episode of A-LOC can contribute to the development and/or reactions of the aircrew to SD [4].

Incidence of G-LOC in flight is known to have caused loss of aircraft and life in most Air Forces [5,6,7]. Aircraft accidents attributed to SD and LSA have continued to be of major concern in combat flying. Possiblity of A-LOC occurring more frequently than G-LOC is a reality, as it is known to occur at relatively low G levels of shorter duration specially if it follows negative G due to push-pull effect (PPE) [2,8]. United States Navy has attributed a large number of in-flight incidents of altered state of awareness to A-LOC [2]. A-LOC has not been implicated in any aircraft incident or accident in the IAF [7,9]. In a study spanning over a decade of high G centrifuge training in the IAF, more than 200 episodes of G-LOC in about 400 pilots have been recorded. The incidence of G-LOC is over 30% but no case of A-LOC has been documented in the study [10]. This paper aims at discussing six episodes of A-LOC that occurred recently during high G training at the Institute of Aerospace Medicine, IAF.

Material and Methods

The Institute of Aerospace Medicine, IAF conducts Advanced Fighter Aircrew Indoctrination Course (AFAIC) for aircrew of fighter stream. As part of the course the aircrew are subjected to high G training in the Department of Acceleration Physiology. The aircrew are trained to perform Anti G straining maneuvers (AGSM) correctly and efficiently. They are expected to sustain 7G for 15 seconds, 8G for 10 and 9G for 5 seconds and undergo simulated air combat maneuvers (SACM) profiles in the human centrifuge [11,12]. The onset and offset rates for these centrifuge runs are 1G/ second respectively. The centrifuge runs are recorded through a close circuit camera placed inside the gondola of the centrifuge. This is then recorded on a video cassette. In the event of an inadvertent G-LOC or request from the aircrew the medical monitor terminates the run. The medical monitor closely monitors the aircrew online on a colour television and is charged with the safety of the run. Safety considerations guide his discretion to terminate the run at any given time even before G-LOC occurs or the aircrew makes a request. G-LOC is not deliberately induced even though there has been no evidence of any post G-LOC pathologic sequels so far at this Institute [10]. The episode of G-LOC is recognised characteristically by sudden loss of postural tone, which causes the head and neck to slump [1]. This, in addition to other recognizable symptoms, prompts the medical monitor to terminate the run. A siren is sounded in the Gondola immediately on occurrence of G-LOC. The pilot is briefed before the run, to switch-off the siren as soon as possible. The video cassettes of the last four courses conducted at the Institute were analysed and six episodes of A-LOC, which inadvertently occurred in five aircrew, were selected for the study. The aircrew were interviewed after the episode of A-LOC and review of literature on A-LOC was done as part of the study.

Results and Discussion

The particulars of the aircrew who had an episode of A-LOC were recorded and these included age, height, weight, flying experience, type of aircraft current on, relaxed rapid onset rate G tolerance and G-level tolerance (Table 1).

Table - 1 : Pilot particulars

Episode	Age (Yrs)	Height (cms)	Weight (Kgs)	Flying Experience (hrs)	Relaxed Tolerance Rapid onset run	G-level Tolerance
1.	27	185	84	600	3.8	7G for 15s
2.	27	169	61	470	4.1	7G for 15s
3.	24	177	62	343	3.1	6G for 30s
4.	24	177	62	343	3.1	6G for 30s
5.	24	171	64	400	3.8	7G for 15s
6.	25	183	67	280	4.1	8G for 10s

The video cassettes were analysed and the episodes of A-LOC were studied by ascertaining the peak G and duration when the episose occurred, the period of A-LOC, the symptoms expressed and observation of the medical monitor were recorded. The period of A-LOC was considered from the time the pilot developed a blank stare and stopped doing AGSM to when he cancelled the siren. The aircrew were interviewed after the episode and were asked to describe the experience (Table 2).

Aircrew were healthy individuals in full flying catergory. Only one aircrew could not successfully complete the mandatory course requirement of sustaining 7G for 15 seconds and minimum of 2 peaks of SACM. 17 episodes of G-LOC and 6 episodes of A-LOC occurred.

We observed that during A-LOC the aircrew developed a characteristic blank look/stare coinciding with cessation of AGSM. It was also accompanied by cessation of verbal response. The eyes however remained open throughout the episode in contrast to that seen in G-LOC. There was no loss of postural tone, which was evident from the fact that their head and neck did not slump. This is in contrast to the characteristic slumping of the head in episodes of G-LOC due to loss of postural tone [1]. The loss in postural tone is supposedly a protective mechanism incorporated during our evolution under the gravito-inertial force of the earth. It causes the lowering of the head below the heart thereby helping in the re-establishment of cerebral circulation [13]. Interestingly confusion and disorientation was a common feature in all cases. There was evidence of amnesia in three of the six cases. One of the aircrew expressed surprise on recovery from the episode. The episodes of A-LOC lasted for a period ranging from 4 seconds to 8 seconds. The episodes occurred at peak G values ranging from 5 to 8 G after a stay of 4 to 10 seconds (Table 2).

All but one aircrew cancelled the siren, which was taken as the end of the period of the incapacitation due to A-LOC. One aircrew took 27 sec to cancel the siren as he did not remember the pre-run briefing to cancel it. None of the aircrew following the episode however, complained of twitching, hearing loss, tingling, numbness or apathy when queried.

A-LOC is a syndrome in the spectrum of symptoms produced due to +Gz stress. It is an entity that is different from gray out, black out and G-LOC. It's operational significance lies in the fact that it alters the state of awareness by impairing

Table - 2 : A-LOC details

Episode	Duration at peak G When it occurred	Period of A-LOC (secs)	Symptoms/Observations
1.	5s at 8G	8	Confused, disoriented and forgot to cancel siren
2.	5s at 7G	7	Could see but couldn't comprehend
3.	4s at 7G	5	Confused, disoriented
4.	7s at 7G	4	Went through Gray out, black out, confused, disoriented
5.	8s at 7G	5	Confused, disoriented
6.	At 6G, 2 s after descent from 8G	5	Appeared surprised, confused, disoriented

cognitive and motor functions without loss of consciousness at relatively low levels of +Gz. Postural tone is maintained in direct contrast to G-LOC. In an episode of G-LOC the input to the stick is lost due to the loss of postural tone, which might help the aircraft off load the +Gz acceleration. Though the possibility of flailing movements causing inadvertent activation of control does exist in G-LOC, in A-LOC, due to preservation of postural tone the input to the stick may persist. Hypothetically this may be counterproductive, as +Gz may not be off loaded. On the contrary it may further tighten the manoeuvre, as all this while the aircrew is relatively incapacitated and lacks situational awareness finally resulting in G-LOC.

A-LOC produces cognitive deficit, which resembles the relative incapacitation symptoms of G-LOC as it manifests in confusion, disorientation, amnesia, psychological suppression (denial), though it lasts for a shorter duration. Many of the symptoms are similar to those experienced during a variety of incidents of SD [4]. SD is a psychophysiologic phenomenon as the stimuli are physiological limitations in the aerial environment and the reaction of the aircrew to SD are psychological. Therefore, it is felt that the altered state of awareness that results from an episode of A-LOC has the potential to contribute to the development and/or alteration of the reaction of the aircrew to SD.

Conclusion

A-LOC is operationally significant as it can happen at relatively lower levels of G loads and alters the state of awareness thereby making the aircrew vulnerable to SD and LSA. This has direct influence on mission completion and safety. Therefore, the pilot and aeromedical community needs to address the problem seriously [14]. Interactive sessions between the combat pilots and squadron aviation medicine specialists through post flight de-briefs, analysis of +Gz profiles flown and it's correlation with the flight path, analysis of cockpit voice recorder, where applicable and application of questionnaire studies will help eliciting the actual frequency and magnitude of the problem in operational combat flying.

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