AVIATION MEDICINE VOLUME 28 NUMBER 1 1984

Fatal Aircraft Accident: A Case Report

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"We should all bear one thing in mind when we talk about an airman who has been killed in a flying accident. He called upon the sum of all his knowledge and made a judgement. He believed in it so strongly that he knowingly bet his life on it. That he was mistaken in his judgement is a tragedy, not stupidity. Every superior and contemporary whoever spoke to him, had an opportunity to influence his judgement, so a little bit of all of us goes in with every airman we lose."

—A 'USAF' Flight Safety poster

It was a bright, clear and cloudless day. The very first prototype of a jet trainer aircraft was pushed out of the hanger of Design and Development Division of the Aircraft Factory for the fifteenth developmental flight.

A young Air Force test pilot got into the cockpit and carried out exhaustive pre-flight checks. He had ample reason to be particularly meticulous. He had flown this aircraft only once earlier—the fourteenth development flight two days back. So nobody grudged when he took almost 45 minutes before taxying out for take-off. The aircraft had an apparently normal take-off, and was soon joined by a Marut aircraft, which was to monitor the prototype's performance externally, for part of the sortie. Both aircrafts climbed to 20,000 feet and carried out integrated exercises for a period of 45 minutes at that altitude. At this point, the prototype aircraft initiated a further climb to 35,000 feet to carry out some more test manoeuvres, whereas the Marut aircraft returned to base as briefed. Till this time everything had appeared normal. The pilot's R/T calls were prompt and sounded normal. Trouble seems to have started soon after this. About 3 mts after the pilot had initiated the climb from 20,000 feet up, the Air Traffic Controller called him up, to enquire "Operations normal". The pilot did reply "Ops normal" but only after repeated calls. Even his reply, though clear and unhurried somehow did not appear normal. Immediately, the ATC officer enquired about his fuel state. The pilot, after repeated calls, gave an incomplete reply, and after that, i.e. 1 min. and 15 seconds after the first call from ATC he stopped replying at all. Nothing was heard from him after this and overdue

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action was taken. A few hours later, the wreckage of the aircraft was reported by Civil Police. The pilot had been killed on impact without any attempt of ejection. Time of crash, as established from on-board Accident Data Recorder, exactly 3 minutes after pilot's last incomplete R/T call.

Subsequent exhaustive and pragmatic investigation brought out some significant and relevant points in the history of the aircraft and in the sequence of events leading to crash.

Aircraft history

In all the previous flights, the aircraft had a record of sub-standard performance of air pressurization system. The cabin leak rates were excessive and at no time was a satisfactory differential pressure achieved. Even the functional compromise figure of 2.9 psi D.P. revised from a Design requirement of 3.5 psi was achieved only at full throttle setting. Reducing the throttle setting resulted in dumping of cabin pressure.

Result

The pilot was exposed to significantly higher cabin altitudes whenever he reduced his throttle setting. To quote an example—while flying at 45,000 feet his cabin would have been at 31,000 feet as against 21,000 feet normally. This figure is based on actual experience during the previous flights. After the 13th flight in which the pilot reported pain in the ears when he reduced throttle at 45,000 feet because of rapid dumping of cabin pressure, a restriction of 32,000 feet maximum altitude was put for further flights. But this restriction was inexplicably waived for 14th and 15th flights in which the aircraft climbed to 35,000 and 37,000 feet respectively.

A second significant point is that a new oxygen regulator was fitted in this aircraft. Although this regulator was a type certified item, the pilot was relatively unfamiliar with it. For one, it required to be selected 'ON' by the pilot—whereas there is no such requirement in any other aircraft in the IAF; the regulator being either wirelocked in 'ON' position or selected 'ON' by the ground crew.

Crash evidence analysis

It was estimated that the aircraft had hit the ground in a 30° dive with a 60° bank at a fairly high speed (300 to 350 kts). The aircraft disintegrated totally on impact, as did the pilot's body. The engine was running at the time of impact, though not necessarily at full power. Laboratory tests ruled out fire or explosion in the air as well as a catastrophic structural failure in the air. This assessment was supported by eye witnesses. Nor was there any indication of a serious control malfunction or failure

Autopsy, histological and toxicological examination on the remains of pilot's body proved non-contributory. No blood or brain tissues were available for lactic acid estimation. Muscle lactic acid was found to be within normal limits.

Most probable cause

Though the exact cause of the accident could not be ascertained beyond reasonable doubt, evidence did form a certain pattern. Just three minutes before the crash, the aircraft was flying fairly high altitude. From that height, the aircraft came down and hit the ground without an ejection and without even an R/T call. Apparently, there was not even an attempt at forced landing or ditching. There was no evidence of such a catastrophic material/control failure in the air that the pilot did not get any time to eject—not even to transmit. A this when he had ample height. And finally, the aircraft had an uncontrolled impact with the ground

All these facts suggest that the pilot was not only not in control of the aircraft at the time of impact but was not fully conscious. How else can one logically explain the aircraft hitting the ground in a steep dive and the pilot neither ejecting nor attempting last minute forced landing.

Considering all these facts, it was inferred that in all likelihood, the pilot was incapacitated in the air. Various causes of incapacitation were considered and ultimately after detailed deliberations and characterization of specific criteria, the Court of Inquiry could not categorically rule out hypoxia or lack of oxygen. Although no direct evidence was available that the pilot actually suffered lack of oxygen, there was sufficient circumstantial evidence to support this line of reasoning.

The pilot was to climb to 35,000 feet but actually climbed to 37,000 feet as evidenced by the on-board, Accident Data Recorder. His cabin altitude at 37,000 would have been 23,000 feet initially, going up to 27,000 feet on throttling back—because of unsatisfactory air pressurisation system. The time at which R/T deterioration was noticed coincides exactly with the time at which the pilot would have been at 35,000 or 37,000 feet. Though the time of useful consciousness at height varies greatly between individuals it is about 2 minutes at 27,000 feet cabin altitude from the time oxygen supply is cut off [1,2,3] if the pilot was breathing only air right from take off, as in this case, the time of useful consciousness will be even less because of 14 minutes stay at 23,000 feet (cabin altitude 17,000 ft). After the pilot became incapacitated the aircraft appears to have descended rapidly and crashed.

The pilot's transmission, "Ops normal" about 4 minutes before crash is very significant. It would either mean that everything was really normal, or that the pilot was not aware of what was happening to him or to his aircraft at that time. Had everything been satisfactory, the aircraft would not have crashed 3 minutes 45 seconds later without any R/T transmission/ejection. In addition, the operations normal call came after pilot's failure to reply to earlier ATC calls. Hence the second possibility that the pilot was indeed suffering from lack of oxygen without being aware of it, is more likely. In this regard, Luft and Noell (1956) have described three phases in anoxic failure, and I quote, "the first being unusual behaviour characterised by automatism ; the subject may behave in a co-ordinated manner but his reaction is out of the ordinary. In the second phase there is sudden loss of consciousness and, in the third, failing postural tone. It is characteristic of anoxia that the subject is wholly unaware of his disability and it is at Luft and Noell's phase I that an accident is likely to be precipitated" (Ref. 4). Unquote. An "Ops normal" call at this juncture when things were anything but normal can thus be explained as being due to "automatism" caused by hypoxia. Immediately following this call, the pilot again faltered in his response to R/T transmissions and completely stopped replying after a garbled call just 45 seconds after "operations Normal" call. This probably was a result of rapid deterioration of pilot's consciousness at that altitude.

Probable cause of Hypoxia

The oxygen system of the aircraft was duly charged and was found serviceable prior to the flight during DI. The contents of the oxygen cylinder which was used to charge the aircraft oxygen system were analysed and showed satisfactory oxygen purity. With the oxygen supply available, the pilot could have suffered from lack of oxygen only under the following conditions:

(i) Malfunction of oxygen regulator in the air,

(ii) Inadvertent disconnection of oxygen tube in the air,

(iii) Failure to select the oxygen regulator 'ON' before take-off, and,

(iv) Inadvertently switching the oxygen regulator 'OFF' in the air.

There was no reason to suspect malfunction of the oxygen regulator. It was a type certified item and was found serviceable during pre-installation checks, previous flights and DI.

The pilot had connected his main and emergency oxygen tubes properly. The 'quick disconnect' connector of the oxygen tube was recovered from the wreckage. It had a portion of emergency oxygen still attached to it. It also showed scoring marks, which corresponded to the female portion of the connector of aircraft oxygen tube. It conclusively proved that the oxygen tube was properly connected up to the time of crash.

Thus, it is possible that either the pilot forgot to select his oxygen regulator 'ON' before take off, or selected it 'OFF' inadvertently. The 'OFF' position before take off appeared more likely as discussed below:

(a) ON/OFF switch was not wirelocked in the 'ON' position as is the practice in all other aircraft, using Mk 17 type oxygen regulators.

(b) The pilot can continue to breathe cockpit air without difficulty even if the regulator is 'OFF' but in 'Airmix' position.

(c) The pressure gauge on the regulator continues to indicate 'full' even with the regulator 'Off', unlike Mk 17 type oxygen regulator. Although the blinker would not operate indicating that the regulator switch is off, the pilot could miss it because of its location, unless voluntary effort was made to check it.

Another aspect that was considered was whether the pilot would have regained consciousness once the aircraft descended to lower altitudes. The recovery from hypoxia will obviously be quite rapid if the subject is administered 100% oxygen—but even then, the recovery time is related to the duration and degree of hypoxia at the start of re-oxygenation. Bryan and Leach (Ref. 4) found that 17 seconds of oxygenation with 100% oxygen was required to reverse the effects of 10 sec of anoxia at 40,000 feet. In the case under discussion, the pilot was breathing only cabin air even during the descent. Time lost in descending through upper altitudes where no appreciable amount of oxygen is available coupled with the fact that even at lower altitudes, only air was available to the pilot, suggested that the pilot could not have regained consciousness to a level which would make him aware of his surroundings and take control of the aircraft before the aircraft hit the ground.

The pilot's muscle lactic acid was found to be within normal limits while his blood and brain tissues were not available for examination. As we know, in the presence of hypoxia, the glycolysis stops at glyceraldehyde 3-phosphate level due to alteration of NAD/NADH ratio. This is compensated by reduction of pyruvate to lactic acid and re-oxygenation of NADH to NAD. NAD thus released is used for continuation of glycolysis. The process is self limiting due to accummulation of lactic acid. Hence the lactic acid levels in the blood, brain and muscle have been used at times as indices of ante-mortem hypoxia. The normal levels of lactic acid are:

Blood	— 200 mg%
Brain	— 6-18 mg%
Muscle	— Variable

But using lactic acid as an index of ante mortem has two main problems. Firstly, the lactic acid formation continues even after somatic death, till cellular death occurs. Hence the tissues not retrieved and frozen immediately after death may show erroneously high figure. Secondly, and more importantly, there is no significant rise in the lactic acid levels with mild to moderate hypoxia or even with severe, short-term hypoxia. In the context of flying, the mild to moderate hypoxia affecting such finer senses as judgement, reaction time and self criticism is much more significant than a long term moderate to severe hypoxia.

It has been pointed out by Mason[4] and Adaval that the lactic acid as an index of hypoxia is very unreliable. Normal and subnormal levels of lactic acid do not necessarily rule out hypoxia. Conversely, high levels of lactic acid do not necessarily provide incontrovertible evidence of antemortem hypoxia.

Conclusion

To summarise, it can be stated that the accident probably occured due to two parallel reasons. First, a sub-standard air pressurization system, but for which the pilot would not have been exposed to unusually high cabin altitudes in the first place. It is relevant to mention here, that if a pilot is breathing only air at any altitude above 20,000 feet, incapacitation due to hypoxia is only a matter of time (ref 1, 2). It is thus not without reason that cabin altitude in most aircraft usually stays below 20,000 or 22,000 feet. The second reason in all likelihood was the failure of the pilot to ensure that his oxygen supply was 'ON', due to whatever reasons. Thus the two fold protection that a pilot normally has against hypoxia—AP system to forestall his exposure to unhealthy altitude, and an oxygen system to kick-in oxygen at higher concentration, should the AP system fail, was lost—first one because of a technical fault, and second one, ironically because of pilot's own fault. And that is what, in all probability lead to disaster and tragedy.

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