ALCOHOL AND FLYING

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Introduction

The deleterious effectsof Alcohol (Ethanol/Ethyl Alcohol) on human task performance have been extensively studied. The neuromotor inco-ordination and poor reflectory control induced by alcohol resulting into subnormal responses have been noted by many workers. Alcohol is known to lower performance in muscular skill, sensory acuity and dull's one's critical judgement and sense of responsibility. Errors of judgement go unnoticed. Decreament of visual and hearing acuities have been noted even at barely estimable blood alcohol levels.

The problems presented by the consumption of alcohol by flyers are among the most complex in aircrew health maintenance. As a socially acceptable relaxant it is not uncommon for the flyers to consume alcohol. Since visual and hearing acuities, muscular so co-ordination and so on, which are all very important human faculties neccessary for flying, get advertisely affected by alcohol, those aircrew who fly after consuming alcohol in the hours preceding the fliget are at grave risk and are a potential cause of flying accidents. Therefore, everyone interested in flight safety agrees that drinking and flying do not mix.

Despite extensive studies that have been carried out on the effects of alcohol on human faculties, several problems related to alcohol and flying still persist. Whereas answer to some of these problems, though available, are not known to many, there are some other problems for which no clear cut answers are as yet forthcoming.

During last year I was associated with the investigations of two civil aircraft accidents. In both cases there were possibilities of alcohol being the cause of accident. During the course of enquiries I faced some problems regarding alcohol and flying which I am presenting to-day.

In the first accident the problem was of interpretation of positive alcohol test whereas in second accident the problem was connected with ingestion of alcohol by aircrew.

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I will now discuss the case histories of accident, with a view to highlight the problems that arose during the course of the enquiries

First Accident

A Fokker Friendship aircraft while attempting to land met with an accident. All the occupants including the pilot were killed. Autopsy examination on the pilot was carried out more than 30 hours later and at the time of autopsy it was observed that the body was showing signs of putrefection. Due to contamination, the blood samples could not be submitted to chemical analysis. However, a qualitative iodoform test for alcohol on the stomach contents yielded a positive result. Based on this finding the chemical examiner opined that the pilot had ingested alcohol. Consequently, ingestion of alcohol by the pilot became a strong possibility as the cause of the accident. Subsequently re-appraisal of the evidence convincingly ruled out this possiblity. The points that required careful reappraisal were, (i) was the substance detected by Iodoform Test really alcohol, ie. the validity of analytical method employed had to be established and (ii) the sour of alcohol, whether indigenously produced or imbibed, had to be established,

Validity of Analytical Method

The chemical test used in this case was Iodoform Test. A positive result depends upon the demonstration of hexagonal Iodoform crystals microscopically and identification by a characteristic smell. In this case such crystals were demonstrable. However, what was ignored in this case was the fact that besides alcohol many other substances such as aldehydes, acetone, amyl alcohol, lactic acid etc., also give similar results. Furthermore, it is also known that in a putrefying body such substances are present. Therefore, the chemical test employed in this case could not establish that the substance detected in the stomach contents was really alcohol.

Source of Alcohol :

Even if it was presumed that the chemical test carried out in this case did correctly detect the presence of alcohol, then it was necessary to establish whether the alcohol had been produced in the body or imbibed. In this case the specimen was collected over 30 hrs. after death and putrefective changes in the body had set in. Much has been written on the subject of the production of ethy alcohol in the body after death. The evidence now is overwhelmingly in favour of the view that true ethanol can be produced in post-mortem tissues by the action of common saprophytic fungi and bacteria including candida, E. Coli pseudomonas, Alkaligenese faecalis,, proteus and so on. Blackmore (1968) in his study on the bacterial production of ethyl alcohol has reported the production of 96 - 153 mgm % of ethyl alcohol within 18 hours. Similarly Bonnichesen et al (1953 could detect true alcohol levels

as high as 390 mgm % in stomach contents and 240 mgm % in blood within 24hrs. It has been stated that post - mortem samples obtained not more than 4 hours after death are probably fairly reliable. Because of these considerations, in this particular case, the cause of this accident to be alcohol ingestion by the pilot could not be established.

The problem in this accident arose because definite conclusions were drawn from the result of chemical test which was a non-specific, crude, qualitative test as well as due importance was not given to the prevalant knowledge that large amounts of ethyl alcohol could be produced by micro-organisms in the body after death.

Needless to say that errors of this kind could have serious repercussions. An innocent pilot may be blamed for causing an accident by the irresponsible behaviour of consuming alcohol before or during flying. Moreover, by ascribing the cause of accident erroneously to alcohol the real cause of accident could easily be missed.

With a view to obviate such mistakes the following sequence of analysis is recommended to be adopted (Blackmore 1968). Only when this is ensured can it be concluded that presence of ethyl alcohol in postmortem material is due to ante-mortem ingestion :—

(a) Blood to be analysed for ethyl alcohol should be cultured. The presence of bacteria would render the sample unsuitable for analysis.

(b) All analysis should be under-taken only by methods specific for ethyl alcohol such as Gaschromatography.

(c) Urine from an intact bladder is the fluid of choice in the absence of glycosuria and proteinuria. The sample should be placed in a glass container with an airtight lid and stored at 40°C until analysed. Ethyl alcohol is not likely to be produced by bacterial contamination of urine.

(d) If urine is not available, blood sampling should be from left and right side of heart and one other peripheral source eg, Femoral artery. The samples should be immediately preserved with 10 mg/ml sodiumfluoride and placed in airtight containers. Should the concentration of ethyl alcohol be the same in all the three samples, the result could be considered to be due to ante-mortem ingestion.

Second Accident :

An instructor and two trainee pilots while performing single-engine circuit and landing training exercise in an AVRO, crashed. All the three occupants were

killed. Postmortem examination was carried out shortly after the crash. Blood and tissue were collected, preserved and chemically analysed for alcohol by recognised quantitative methods. The value of alcohol estimated in this case were therefore valid for ethyl alcohol. Inquiries revealed that immediately before flight all the three flyers along with a few friends had consumed about 7 or 8 pegs of whisky and 9 or 10 bottles of beer. The exact quantity ingested by each individual could not be confirmed.

Chemical examiners'report revealed the following blood alcohol levels :—

(1) Capt I (Instructor)	14.4	mgm %
(2) Shri S (Student)	20	mgm %
(3) Shri R (Student)	94	mgm %

During enquiry the following questions regarding interpretation of alcohol levels had to be settled :—

(1) Determine the amount of alcohol ingested by each by back calculations.

(2) Determine the time interval between the last drink and onset of flying ?

(3) And what are the permissible blood alcohol levels for flying ?

Unlike the first accident, where clear cut answers were available, the answers to the above questions were debatable.

A brief review of the available information on the subject is therefore essential :—

(1) Problem of back calculation :—

When alcohol is consumed, it undergoes a process of distribution through out the body which can be influenced by many factors. Alcohol is first absorbed by passive diffusion through gastro-intestinal mucosa into the blood and re-distributed from the blood to all tissues, coming eventually to a uniform concentration through out the body. At the same time some alcohol is lost in the water vapour of breath in sweet and urine. A larger amount diffuses into liver and other tissues in which enzymatic breakdown of alcohol occurs.

After absorption is complete and the blood level begins to fall alcohol diffuses back from those tissues and fluids in which no metabolism occurs, into those in which metabolism or excretion takes place. The balance between absorption, distribution, metabolism and excretion determines the alcohol level in any given tissue or fluid at any given time after ingestion. In

addition, with postmortem samples, it is also to be remembered that there is possibility of further alteration resulting from local bio-chemical activity for varying period after death, either by metabolic removal of alcohol, or by new formation of alcohol. Each of these factors create a problem which makes it very difficult to answer the questions referred to above.

Absorption :

The passive diffusion of alcohol across a mucous membrane depends upon the concentration gradient between the two sides of the membrane and the permeability of the membrane itself. Therefore, the speed of absorption can be markedly influenced by anything that affects either the gradient, or the membrane which must be crossed. Some of the factors that may affect absorption are,

(a) Concentration of the alcohol

(b) Fatty food and milk.

(c) Adrenalin.

(d) Severe muscular exercise.

(e) All factors reducing gastric motility

(f) Pylorospasm.

Thus the difficulty, to back calculate from an observed blood alcohol level the amount of alcohol ingested or the time when ingested is obvius.

However in an average case it is kown that the peak blood alcohol level is reached in ½ to 2 hours and in urine about 20 - 30 minutes after peak blood level.

Distribution :

From the blood, the alcohol diffuses into the body tissues and fluids and only when an equillibrium is reached that alcohol is distributed in the body at a uniform concentration. Being a dynamic process such concentrations in various parts of the body are variable from time to time. It therefore follows that a single observed value of blood alcohol is not adequate for allowing for an accurate back calculation regarding the amount of alcohol ingested.

Rate of alcohol metabolism :

There is a general agreement that the metabolism of ethanol proceeds almost exclusively via the oxidative activity of alcohol dehydrogenase and that alcohol usually disappears from the body at a constant rate independent of its initial level. However, it is also noted that the rate of alcohol oxidation from one subject to another or even within the same subject varies on different occasions due to nutritional and metabolic factors. Animal experimentation have shown deviation upto 15 - 20% of the mean value.

On an average, it has been found that 90 - 95% of alcohol is metabolised in the liver @ of about 9 - 15 ml/hr that is @ 100 mgm/Kg/hour. As a rough rule the rate of metabolism is calculated as one peg of whisky in 3 hours. This is, however, only a very rough guide. To back calculate from a single alcohol value to an estimated value several hours earlier is extremely difficult and the range of error one might encounter may be significantly large. Any attempt to back calculation in the context of alcohol ingestion in relation with flying should be done with extreme caution.

Time interval between last drink and onset of flying :

Since alcohol has deleterious effects on flying performance it is universally recommended that alcohol should not be consumed by the flyer before undertaking a flight. With this in view rules have been framed to forbid flyers from ingesting alcohol prior to flying all over the world. For example,

(a) In UK, there is a restriction on pilots not to fly for 8 hrs after taking moderate amount of alcohol vide Aeronautical Information Circular No. 32/1972 but what moderate drinking means is not mentioned.

(b) USA – 12 hrs (Federal Aviation Act)

(c) India - 12 hrs. (1937) (Indian Aircraft Act)

Furthermore, Farmer (Aerospace Medicine 1972) has recently stated that 16 hrs. or more is required for all alcohol in the blood to be metabolished and this has been suggested as a reasonable abstinence period. The total quantity ingested however, influences the time for metabolism. When more than 4 ounce of alcohol has been ingested, at least 24 hrs should elapse before flyer returns to flying.

Thus, the question as to **how much** time interval should elapse after ingestion of alcohol before flying is undertaken by a flyer is not yet clearly answered.

3) Permissible blood alcohol level for flying :

In different countries different blood alcohol levels are laid down by law below which driving of cars after ingestion of alcohol is legally permitted. Some of these are,

Norway	50	mgm %
UK and Sweden	80	mgm %
Denmark	100	mgm %
USA	150	mgm %

However, deterioration in human functions in relation to task resembling car driving has been reported by some worker at even as low levels of blood alcohol as 10-80 mgm % (Drew) 30 mgm % (Loomis and West) and 40-50 mgm % (Bjerner and Goldberg).

In the case of flying no rules regarding permissible limits of blood alcohol at present exist. However, Aksnes (1954) noted that complicated skill tests such as a U-track task in a link trainer deteriorated at about 50 mgm % blood alcohol levels and also pointed out that one must be prepared for lowered ability to perform a skilled test with alcohol levels around 20 mgm %. Horper & Albers (1964) have stated that flying skills are measurably decreased by only onefourth the amount of alcohol necessary to produce measurable decrease in driving skills that is at about 25 - 40 mgm %. These figures are further supported by a very recent study by Billing et al (1973) who found serious decrementl in flying performance at 40 mgm % blood alcohol level. Workers from West Germany (Krefft 1969) consider 20 mgm % as the upper blood alcohol limit over which flying performance gets deteriorated.

Thus, answer to the question of permissible blood alcohol levels in relation to flying is not clear. It appears that above 40 mgm % blood alcohol levels, flying is definitely dangerous but whether alcohol levels lower than this should beonsidered dangerous for flying requires further clarification.

In the case of the second accident, therefore, there was no doubt that one of the pilots (over 90 mgm %) had a blood alcohol level which could be interpreted as positively dangerous for flying where-as in the case of the other two no definite opinion could be expressed.

Conclusions :

Extensive studies have established that human skills get adversely affected by alcohol. Flying being a highly complex and skilled task, the adverse effects of alcohol are observed at relatively low levels of blood alcohol. As different blood alcohol levels at which deterioration in human performance occurs are found to be different in various countries, it becomes extremelydifficult to opine whether a particular blood alcohol level found in a pilot could be considered dangerous for flying or not. Number of factors influence absorption, distribution and metabolism of alcohol in the body and hence it is very difficult to calculate back the amount and time of alcohol consumption from a given blood alcohol level. Recent studies carried out on the affect on flying performance indicate that blood alcohol levels of 40 mgm % and above should be considered to be positively dangerous for flying. One must however, be prepared for lowered ability to perform skilled tasks at blood alcohol levels around 20

mgm %. The interpretation of alcohol levels determined from postmortem tissues/fluids should be done with due caution after taking into consideration factors such as the specificity of methodology employed and presence of bacterial contamination.

REFERENCES

1 Aeronautical Information Circular UK (32/1972) Alcohol and Flying.

2 Aksnes, E. G. (1954), *J. Av. Med.* 25, 680-688/693.

3 Billing et al (1973) *Aerospace Medicine* 379 - 382

4 Blackmore, D. J. (1968) *J. For. Sc. Soc.* 8 : 73 - 78

5 Camps, F. E. (1968) Gradwohl's Legal Medicine, Bristol, John Wright & Sons Ltd.,

6 Davis, G. L. (1968) *Aero Space Medicine* 39 : 869 - 872.

7 Drew, G. C. Colquon, W. P. and Long H. A. (1958) *Brit. Med. J.* 2 :

8 Farmer, R. A. (1971) *Aerospace Medicine*, The Williams & Wilkins Company Baltimore 2nd edition (edited by Randel HW)

9 Goodman, L S Filman, A, (1970) the pharmocological Basis of Therapeutics : London, 4th Ed. The Macmillan Company.

10 Harper, CR, Albers, W. R. (1964) *Aerospace Medicine* 35, 462 - 464.

11 Indian Aircraft Act (1937).

12 Kalant, H. (1968) *Aerospace Medicine* 39 : 633 - 637

13 Krefft. S. (1969) Wehrmed Monatsch 7 : 200, 3.

14 Modi, N J (1969), Modi's text book of Medical Jurisprudence and Toxicology, Bombay, N. M. Tripathi Private Ltd.,

15 Mohler, SR., Berner, WH. Goldbaum, I.R (1968) *Aerospace Medicine* 39 : 1228 - 1230.

16 Stevens, P J (1970) Fatal Civil Aircraft Accidents, Bristol, John Wright and Sons Ltd.,