PHYSIOLOGY OF ALCOHOL

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Introduction

IN this symposium when the term 'alcohol' is mentioned, it is restricted to Aliphatic alcohols and amongst them 'ethyl alcohol', also popularly known in scientific parlance as 'ethanol', which has a chemical formula C_2H_2 OH.

Historical—The attraction of man to 'alcohol' has existed throughout history, since man's coming into being. Alcohol was considered the long sought elixir of life and therefore a panacea for all types of ills/illnesses, of the man and the world. The term 'whisky', therefore, came into being, (Gaelic —Usquebagh), meaning "Water of Life". The ancient Indians called it Somarasa, the Japanese Sake, the Greeks and Romans gave a higher special status than by giving a mere name, by dedicating wines to their gods.

Horace wrote,
"What wonders does not Wine'.
It discloses secrets; ratifies and confirms our hopes;
Thrusts the coward forth to the battle;
Eases the anxious mind of its burden;
Instructs in arts.

Even in the present day world, alcohol has become more or less a social and cultural necessity and a social symbol.

Aetiological Factors

Alcoholism is now recognised as a "disease entity" by the medical profession and W.H.O. It is a chronic illness, psychic or somatic or psychosomatic, which manifests itself as a behavioural disorder.

Several etiological factors have been incriminated for this malady, such as nutritional deficiency, Vit 'B' deficiency, genetic, masked allergy to alcohol and so on. The fact, that so many theories are postulated, point to our inability ultimately to find a single cause modalities for the highly complex behavioural disorder. The physiological philosophy is that "it is the effect of alcohol that is sought by an alcoholic, rather than the fulfilment of a structural deficiency."

Absorption, Metabolism and Elimination

Mechanics of Absorption— Alcohol is rapidly absorbed from the stomach, small intestine and colon. Vaporised alcohol can be absorbed through the lungs to fatal intoxication levels. The rate of absorption from the stomach, however, depends on several factors like the presence of food, period of time taken for the ingestion of drink, the volume, character and concentration of alcoholic beverage and the individual peculiarities. Complete absorption from stomach thus takes about 2–6 hours. Absorption from small intestine, however, is rapid and complete, irrespective of the concentration of alcohol, presence of food, etc.

After absorption, alcohol is uniformly distributed throughout all tissues and fluids of the body and immediately produces effects on the CNS. As much as 300-500 mg % of alcohol concentration occurs in the brains of persons dying of alcoholic intoxication.

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Metabolism—90 to 98% alcohol that enters the body is completely oxidised and the peculiarity is that the rate of oxidation is a linear function of time. In an adult, the average rate of metabolism of alcohol is about 10 mg%/hour, i.e. alcohol in 4 oz of whisky requires about 5 to 6 hours for oxidation.

Certain dietary and hormonal factors are known to alter the metabolism of alcohol—for example, starvation lowers, insulin increases. Surprisingly, thyroxine has no effect on the rate of oxidation.

The liver is the chief site where alcohol is initially oxidised. The first step is oxidation of alcohol to acetaldehyde by alcohol dehydrogenase. This is a zinc containing enzyme, which utilizes Nicotine Amide Adenine Dinucleotide (formerly known as DPN—Diphospho Pyridine Nucleotide) as the hydrogen acceptor. The acetaldehyde is converted to acetylcoenzyme A (acetyl CoA) probably directly or through acetic acid. This acetyl CoA joins the pool of other acetyl CoA produced from other sources and gets oxidised through citric acid cycle or may be utilised in various anabolic reactions of the body, involved in the synthesis of cholesterol, fatty acids and other tissue constituents. Recent C^{14} studies in normally fed rats revealed that 'ethanol' was more efficient than acetate as a precursor of tissue glycogen, protein, cholesterol and fatty acids.

Many other metabolic changes have been observed to accompany or follow the metabolism of alcohol—such as increased production of lactate and fatty acids and increased uric acid levels. Increased NDH_2 : NAD ratio, which occurs in oxidation of alcohol, may possibly be the cause for decreased hepatic citric acid cycle activity and decreased fatty acid oxidation. It has also been noted in alcohol metabolism—a decrease in urinary excretion of uric acid and increased urinary loss of magnesium, the causes for which are obscure or not known.

Elimination—Destruction and elimination begins soon after absorption. As stated earlier, 90% is oxidised in the liver and about 10% excreted in lungs and kidneys in an unchanged form. Oxidation proceeds uniformly irrespective of energy needs of the body. Thus, if the rate of consumption is equal to rate of oxidation, alcohol does not accumulate in the body and, therefore, chances of its effect on the CNS are less. Since the rate of oxidation is relatively constant, efforts by physicians to treat cases of alcoholic intoxication by diuretics may, therefore, be futile.

Effects on CNS

The primary and immediate effect of alcohol is on the CNS, with which we are mostly concerned in this symposium. It is a CNS depressant, contrary to the popular opinion and thinking among lay people. It is a primary and continuous depressant of CNS and the apparent feeling of stimulation is due to the unrestrained activity of the lower centres of the brain, which have been freed temporarily from the controlling higher centres.

Electrophysiological studies show that it is the more primitive parts of the brain that are more sensitive to alcohol than the cortex—namely the reticular activating system. This system is responsible for most of the integration of activity of various parts of the nervous system and is mostly depressed by alcohol.

The cortex is thus temporarily isolated from the integrating system, resulting in disorganised, jumbled and disrupted thought processes. The first mental processes to be affected are those that depend on (a) Training and previous experience and (b) those that usually make for sobriety and self-restraint.

The finer grades of discrimination, memory, concentration and insight are first dulled and then lost. The descent to a lower scale of values brings personalities of all kinds to a lowest common denominator, an undifferentiated level of behaviour, in which all are equal and find companionship easy.

"Confidence abounds, the personality becomes expansive and vivacious and speech may become eloquent and occasionally brilliant. Mood swings are uncontrolled and emotional out-bursts frequent." These psychic changes are accompanied by sensory and motor disturbances.

Initially, the spinal reflexes may be enhanced due to their being released or freed from central inhibition, followed by general impairment of nervous function merging into a state of general anaesthesia.

The depressed CNS state is evidenced by significant performance decrements even in crude tests like typewriting, target practice and simple mental tasks—not to talk of delicate psychometric tests which require finer skills and mental alertness. Familiar and habitual tasks requiring less skill, thought and attention are less markedly affected.

In general, the effects of alcohol on CNS are proportional to the concentration of Alcohol in blood. It may be noted that the effects are more marked when the concentration is rising than when it is falling.

Effects of Alcohol Vis-A-Vis the Levels in the Blood

Amount of Alcohol	Alcohol conc. in blood per cent	Time for most of the alcohol to be metabolised in the body	Effects
1 Whiskey 1 Cocktail 5½ oz. Wine 2 bottles beer	0.03	2 hours	Slight changes in feeling.
2 Whiskeys 2 Cocktails 11 oz wine 2 bottles beer	0.06	4 hours	Feeling of warmth — mental relaxation.
3 Whiskeys 3 Cocktails 16½ oz. wine 6 bottles beer	0.09	6 hours	Exaggerated emotional outbursts and behaviour. Talkative, noisy or morose.
4 Whiskeys 4 Cocktails 22 oz. wine 8 bottles beer	0.12	8 hours	Clumsiness, unsteadiness in standing or walking. Neuro muscular incoordination, poor judgment, etc.
5 Whiskeys 5 Cocktails 27½ oz. wine 10 bottles beer	0.15	10 hours	Gross intoxication.

Alcohol and Flying

The effects of alcohol on normal persons, depending on blood alcohol levels, have been discussed. It is seen that on the ground itself, performance decrements of humans, even on crude and less skilful tasks, have been considerable. Under flying environment, with all the associated stresses like hypoxia, noise, vibration, 'G' stress etc., which require skilled tasks upto perfection, the performance decrements have been found to be much more accentuated.

The performance decrements may be in any sensory field—visual, auditory, vestibular, tactile

sensation, etc., which cumulatively may cause gross performance decrement in the flying task and thus pose flight hazard.

(a) Visual and Vestibular Problems under 'G' Stress—It has been found that in a target task given to subjects under 'G' stresses (5-6G), with blood alcohol levels of 0.09%, the subjects complained of target 'fluttering up and down' giving a jerky motion picture and some had blurred vision. Vertical nystagmus was observed in these subjects, which corresponds to phase I nystagmus response of "positional alcohol nystagmus". This impairment was found to appear 30 minutes after alcohol ingestion and last for about 3 to 4 hours. The physiological basis for blurred vision could be due to ocular muscle imbalance which occurs prior to double vision.

(b) Alcohol decreases 'blackout' tolerance and increases the incidence of nausea and disorientation in subjects exposed to 'G' stresses.

(c) Performance tasks — Shortlived performance tasks,—simulating aircraft manoeuvres with experienced and inexperienced pilots under low 'G' stresses with alcohol ingestion, have shown considerable performance decrements.

(d) In simple tracking task experiments the reduction in task performance was found to be in the order of 21%, when the subjects have ingested about 3 ozs alcohol with a mean blood alcohol of 0.12%.

Conclusion

Thus it is seen that human performance decrement with alcohol in handling the multiple delicate controls of modern aircraft under flying stresses, is a matter of serious concern. It is evident that disturbances in human activity may occur both in perception, evaluation of information and in the motor responses. Insignificant doses of alcohol consumed before flight or its after effects contribute to inflight emergencies. Knowledge and appreciation of this problem, both by the aircrew and Medical Officers of the Air Force, is essential for safety and underlines the need for Medical Officers of the Air Force to update their knowledge of alcohol and its effects in flying environment.

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