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Physiology of Ethyl Alcohol

*Lewis H. Bronson**

ETHYL ALCOHOL IS PRESENT in certain beverages available for human ingestion, in concentrations varying from 5% to 50%. Beers and wines are the results of natural fermentation and normally contain 5%-10% alcohol, respectively. Some of the "fortified" wines contain up to 20% alcohol, obtained by natural fermentation after the addition of sugar to fruit. "Spiritous liquors" contain 40%-50% alcohol (80-100 proof), obtained by distillation of grains or fruits, resulting often in a product containing about 75% alcohol. This is then diluted to the desired per cent prior to marketing. Some beverages are stored in charred wooden casks in order to absorb certain by-products which affect the taste of the beverage in question. These substances, although toxic in higher concentration, are not present in significant quantities and therefore have no apparent harmful effect.

The physiological effects of ethyl alcohol depend almost entirely on its concentration in the blood stream. This concentration, expressed in per cent, is referred to as the blood alcohol level and has become of increasing medico-legal importance in determining the degree of alcoholic intoxication.

The main factors determining the blood alcohol level are:

1. Amount ingested
2. Concentration in and type of vehicle
3. Presence, or absence, of food in stomach
4. Action of stomach
5. Time required for ingestion (elapsed time)
6. The size of the individual doing the drinking.

Assuming immediate absorption, 10 cc. of whiskey will raise the blood alcohol .01% or 100 cc. of alcohol will result in a blood alcohol of .1%. If the alcohol is present as a 50% solution (100 proof whiskey), it will be more rapidly absorbed than if it is in a 5% solution (beer). If alcohol is ingested on an empty stomach,

* M.D., Yale School of Medicine. In private practice of Internal Medicine, with Alcoholism as a sub-specialty, working with Cleveland Center on Alcoholism. Consultant on problems of alcoholism for City of Cleveland, under direction of Dr. Lavinia Warner, Director of Health & Welfare, and Dr. W. Glen Smith, Commissioner of Health. Clinical Instructor in Internal Medicine, Western Reserve University Medical School. Assistant Physician, University Hospital.

it will enter the blood stream more quickly and produce more of an effect on the blood level than if the same amount is taken with food or with a full stomach.

Maximum absorption will occur after alcohol has passed from stomach into the small intestine. Delay of this passage will delay increase of alcohol absorption into blood stream.

Obviously it makes a difference if an individual drinks a given amount in one hour or in five hours. Alcohol is oxidized at the rate of 10 cc. per hour; so in five hours blood level would fall .05%.

A fairly accurate estimate of expected blood alcohol level can be made by using the following formula: Bl. Alc. % = .001 (A-10H)

A = cc's. alcohol ingested; $33\frac{1}{3}$ cc's = 1 shot

H = elapsed drinking time in hours

e.g., When A = 200 and H = 5, Bl. Alc. = .15%

This assumes that the individual is of average size, that the alcohol has been completely absorbed from the gastro-intestinal tract, and that the individual has normal liver function.

Experimental evidence indicates that 90%-98% of the alcohol ingested is oxidized in the liver. The rate of this reaction is at a maximum when accompanied by simultaneous breakdown of glucose due to its interaction with insulin. Regardless of the height of blood alcohol level, an individual will oxidize about 10 cc. per hour; i.e., blood alcohol level will fall .01% per hour, assuming of course normal liver function. The alcoholic with impaired liver function may oxidize alcohol much more slowly.

It is apparent, therefore, that the speed of ingestion, assuming rapid absorption, is often much greater than the speed of elimination, and consequently excessive use of alcohol may result in a steadily rising blood alcohol level and consequently a rising degree of alcoholic intoxication.

It is known that on absorption into the blood stream 10 cc. of alcohol will result in a blood level of about .01%; 100 cc. = .1%, etc. [100 cc. alcohol (3 ounces) = 200 cc. whiskey (6 ounces)]. Also, assuming an oxidation rate of 10 cc. an hour, 100 cc. would require approximately 10 hours to be eliminated completely. This accounts for the lasting effect of 2-3 drinks. 120-180 cc. whiskey (2 ounces each) = 60-90 cc. alcohol and would produce a blood level of .06%-0.09% which is sufficient to make one "Under the influence." A blood level of .15% is prima facie evidence of driving while intoxicated in many States. This level could result from

the quick ingestion of 5 ounces of alcohol or 10 ounces of whiskey, assuming immediate absorption.

As a rule, a man weighing 160 lbs. is very drunk and unable to walk satisfactorily at blood levels above .25%. This same man would be comatose at levels of .4% or above. The lethal blood level of alcohol varies between .5% and .8%.

There is no evidence to support the view that there is any significant physiological difference between the action of alcohol in alcoholic and non-alcoholic individuals of the same age group. One possible exception to this idea is in "heavy drinkers," whose tissues may gradually develop a tolerance to alcohol and who may be able to function at somewhat higher alcoholic levels than "occasional drinkers." This is especially likely to be true when "heavy" and "light" drinkers of the same age are compared as to ability to function at blood alcohol levels less than .25%.

The steps of the oxidation process are as follows: Alcohol O_2 acetaldehyde O_2 acetic acid O_2 carbon dioxide and water. The two end products (carbon dioxide and water) are eliminated from the lungs and kidneys. Certain drugs, if present in the blood stream of an individual, will prevent the normal detoxification of any alcohol ingested. As a result, acetaldehyde accumulates in the blood stream and tissues of such a patient, producing very severe vomiting, sweating, shortness of breath, and intense burning and itching of the skin and ocular mucous membranes of several hours' duration. Disulfiram or antabuse is one such drug, and when taken daily by mouth will produce such a reaction five to ten minutes subsequent to the ingestion of an ounce of whiskey (15 cc. alcohol). Consequently, anybody who is taking disulfiram not only eliminates any possible pleasure from the ingestion of alcohol but also is physically unable to retain more than one drink and this one drink for a maximum of 10-15 minutes. Therefore, escape via alcoholic coma is made impossible.

In case of doubt, this reaction may be used in reverse and the presence or absence of ethyl alcohol in the blood stream and tissues of a living individual may be established with absolute certainty by observing symptoms subsequent to the ingestion of a *single tablet* (never more) of this drug—disulfiram. The absence of symptoms described above would indicate the absence of ethyl alcohol.

Ethyl alcohol (Ethanol) has many different pharmacological effects. Its local use as an antiseptic is well known and it is

bacteriacidal in concentrations which are 70% by weight. A solution of alcohol below 60% and above 80% by weight has little, if any, bacteriacidal action.

Perhaps the major pharmacological effects of ethyl alcohol are those on the central nervous system. Contrary to popular belief, alcohol is a depressant and not a stimulant. It has a similar action on the brain that many of the general anesthetics have. It is not a frequently used anesthetic, however, because in anesthesia a satisfactory level is only reached shortly before a lethal blood level is obtained. Another great disadvantage of alcohol as an anesthetic is the fact that it is primarily eliminated from the body by oxidation and not given off in the lungs as is the case with the volatile general anesthetics.

The psychic effects of ethanol are of greatest interest, perhaps, in our attempt to understand the problem of alcoholism as we are facing it today. The depression of the highest faculties of the human mind, the warping of judgment and the loss of memory, especially in regard to previous experiences, play an important role in so-called alcoholic thinking. When only moderately intoxicated, although the individual may think his performance is outstanding, his efficiency of operation is greatly decreased. This is also due to the effect of alcohol on the higher centers of the brain.

Alcohol also affects the lowest centers of the brain; and death, if it occurs from overwhelming alcohol intoxication, is usually the result of paralysis of the respiratory center in the medulla.

Other effects of alcohol as a drug on the human body are:

1. There is slight increase in peripheral blood flow which in extreme cases may actually result in lowering body temperature.
2. Possible dilation of the coronary arteries which may be beneficial in certain cases of angina.
3. Irritative effects on the gastro-intestinal tract.
4. Increased flow of digestive juices when dilute solutions of alcohol are ingested, and disturbances of bowels, either constipation or diarrhea.
5. Alcohol acts as a diuretic by depressing the production of the anti-diuretic hormones in the posterior pituitary.
6. Effect on sexual function. One of the better descriptions of this was written several centuries ago by a gentleman by the name of William Shakespeare in *Macbeth*:

“Macduff: ‘What three things does drink especially provoke?’

“Porter: ‘Merry, sir, nose painting, sleep and urine. Lechery, sir, it provokes and unprovokes. It provokes the desire but takes away the performance.’”

In addition to alcohol's function as a drug, attention should be called to the fact that it is also utilized by human beings as a food. The oxidation of alcohol will produce seven calories per gram, that is to say, considerably more than an equal amount of protein or carbohydrate, and a little less than is produced by an equal amount of fat. However, it is not stored in the human body but is used immediately at a rather slow rate of speed. Consequently, its value as a food is limited, although if sudden energy is necessary, it can be quite helpful, since no digestion is necessary prior to utilization.

According to recent reports from the Federal Bureau of Vital Statistics, Alcoholism ranks among the four major National Health threats of the second half of the Twentieth Century, along with Cancer, Mental Illness and Heart Disease. As compared to the other three, it ought to be a problem easily susceptible to rather simple measures of control. After all, most toxic drugs, poisons, etc. are well controlled by National Food and Drug Laws. Even addiction to narcotics has become much less a problem than it was ten-twenty years ago.

It is apparent that the answer does not lie in application of what is known concerning the physiological, toxicological, or pharmacological effects of this drug, nor in our recognition that malnutrition and avitaminosis may play an important part in producing some of the significant pathological changes found by post mortem studies made upon individuals succumbing to this form of disease.

Years of study by many investigators, plus thousands of dollars for medical, psychiatric and sociological research, have been successful only to a very limited degree in preventing, treating, or curing alcoholism. One accomplishment has been to stimulate a gradually increasing awareness by the peoples of the world of the enormity of this problem. In spite of this increased awareness, the problem is getting worse rather than better. Treatment techniques of the condition may have improved somewhat, but it is the feeling of most of the “experts” in this field that real success will come only with a complete physiological understanding of why one man's drink is another man's poison!