Maximal Consumption of Ethyl Alcohol

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Physicians who have had to deal with patients suffering from chronic alcoholism cannot but have been impressed with the wide variation in estimates given by them when asked how much they drink daily. In general, they fall into one of two classes: those who state that they never take more than a couple of beers, and those who stoutly maintain that they consume up to 2 qt of whisky every 24 hr. In order to have some basis for judging the credibility of these statements, it would be desirable to know with a fair degree of accuracy the maximum amount of alcohol that can be consumed daily over a period of several days.

Simple as the direct experimental approach to the problem would seem to be, the medical literature fails to record such an experiment. In default of such direct appraisal, which should certainly some day be made, there is available a sufficient amount of data bearing on the subject to allow us to estimate the maximal daily intake with a reasonable probability of accuracy.

Widmark (*7*) estimated, on the basis of the rate of fall of blood alcohol concentration after a single dose, that a 70-kg man should be able to dispose of 170 g of alcohol in 24 hr, which would imply a rate of alcohol metabolism of 101 mg/kg/hr. If Widmark's estimate is accurate, we must conclude that the greatest amount of 100 proof whisky that a man of average weight could metabolize in a day would be 14 oz, or less than a pint, which would certainly render inaccurate the estimates frequently given of a consumption several times this great. Nor can it be argued that the greater capacity claimed by addicts may be due to increased facility in alcohol metabolism engendered by habituation, for this has been found not to be the case (*3*).

Before we prematurely discredit the patients' statements, however, we must consider an important factor which probably operated to make Widmark's estimate too low. This is the finding, recently confirmed (*1*, *4*), that the rate of alcohol metabolism is not constant irrespective of dosage, as Widmark believed, but that it increases with increasing blood alcohol concentration. Thus Eggleton (*1*) found by referring back to Mellanby's original work (*2*) that in the dog, when the blood alcohol concentration was between 300 and 400 mg/100 cc, the rate of alcohol metabolism was 200 mg/kg/hr; whereas when the concentration was between 200 and 300 mg/100 cc, the rate was only 150 mg/kg/hr. Similarly Newman and Lehman (*5*) found that, considering the average for four dogs, an increase in dosage of 100%, which would double the average blood alcohol concentration, produced an increase in rate of alcohol metabolism of 36%. This has since been confirmed by Newman, Yee, and Cutting (*6*). Since most of Widmark's work was done with small doses of alcohol, the increase in rate of metabolism with increasing dosage may well be responsible for the low estimate of maximal daily consumption reported by this generally reliable worker.

That maximal daily consumption is indeed higher than that put forward by Widmark is supported by the amount of alcohol that has been consumed day after day by dogs in this laboratory. Thus three dogs were allowed access at all times to a solution of 5% by volume of ethyl alcohol in tap water as their sole source of fluid. Under these circumstances they consumed alcohol at a rate of 4.46 g/kg/day. When the percentage of alcohol was raised to 10% they reduced their fluid intake accordingly, so that their alcohol intake increased only to 5.52 g/kg/day. This is equivalent to 230 mg/kg/hr, which is quite a close approximation to the 200 mg/kg/hr that was found by Mellanby with high alcohol dosage. If we transpose this to man, the maximal daily dosage for a 70-kg man can be calculated to be 386 g of alcohol, or approximately 32 oz of 100 proof whisky. This is much nearer the intake claimed by many alcoholics.

A reasonable criticism of the above inference is that so far no evidence has been put forward to justify equating the rate of alcohol metabolism in dog and man. There is, however, fairly conclusive evidence that such an equation is tenable. Thus Newman and Lehman (*5*) found as the average for two human subjects after a dose of 1.5 g/kg, a rate of metabolism equal to 214 mg of alcohol/kg/hr, quite comparable to the figures for dogs which we have quoted. Thus it seems quite reasonable to assume that the rate of metabolism of alcohol in man and in the dog is essentially the same.

Further evidence regarding the rate at which alcohol can be metabolized in dogs may be secured from the following experiments. A 23-kg male dog was given a dose of 3.0 g of alcohol intravenously, and the blood alcohol concentration followed until it approached zero. The average rate of metabolism of alcohol so determined was found to be 156 mg/kg/hr. On another day the same dose was again given, followed by a constant intravenous infusion at a rate of 156 mg/kg/hr for a period of 3 hr. The blood alcohol concentration under these circumstances dropped from an initial figure of 363 mg/100 cc at the start of the constant infusion to 351 at the end. On two other occasions an initial dose of the same magnitude was given, followed by hourly doses administered by stomach tube at the same rate of 156 mg/kg/hr for a period of 8 hr. On one occasion the blood alcohol concentration dropped from 346 to 312 mg/100 cc, on the other from 330 to 312. Thus, in spite of the maintenance dose of 156 mg/kg/hr, calculated from the average rate of disappearance of alcohol after a single large dose, there was, on the average, a drop in blood alcohol concentration of 3.5 mg/100 cc/hr, which is equal to a rate of metabolism of 30 mg/kg/hr in excess of the maintenance dose. The experiment thus demonstrated that a maintenance dose of alcohol calculated from the average rate of metabolism after a single large dose was not sufficient to maintain the blood alcohol level constant at the highest level produced by such a dose. This constitutes additional proof of the fallacy of the hypothesis that the rate of alcohol metabolism is unrelated to dosage or blood alcohol concentration. The true rate of alcohol metabolism at this high blood alcohol concentration can thus be estimated as the sum of the maintenance dose of 156 mg/kg/hr plus the deficit of 30 mg/kg/hr, or 186 mg/kg/hr. If this rate be applied directly to man, the maximal daily consumption for a 70-kg man would be 312.5 g of alcohol, or about 26½ oz of 100 proof whisky, which falls in the same order of magnitude as the 32 oz calculated from prolonged daily consumption in dogs.

From these data we may then conclude that the maximum daily consumption of alcohol by a man of average weight is represented by a quart of 100 proof liquor, and that estimates greater than this are in error. Equally, it may be concluded that this consumption may only be achieved by maintaining the blood alcohol concentration at a high level.

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Preliminary Observations on the Biological Effects of Radiation on the Life Cycle of *Trichinella spiralis*

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Trichinella spiralis is the causative agent of human trichinosis. The disease is acquired as a result of eating undercooked meat, usually pork, containing the parasite in the encysted larval stage. Trichina infection appears to be somewhat common in the United States as it has been found in 14.34% of human post-mortem examinations (*2*). Since there is no simple economical method of treating meat at slaughter to kill trichinae larvae, any information which may improve present conditions is desirable. It has been found that a very intense beam of X-rays or cathode rays produced in a newly developed high voltage machine rapidly destroyed bacteria, yeasts, and molds, and the application of this method to the sterilization of food has been suggested (*1, 3*).

The writers, in this study, have undertaken some preliminary experiments to determine whether treatment of meat with radiations would have lethal action on the encysted trichinae larvae or would produce some morphological change which would prove detrimental to the life cycle of the parasite. For the purpose of clarity the life cycle of *Trichinella spiralis* is briefly summarized. The

FIG. 1. Adult females of *Trichinella spiralis* recovered from small intestine of rats 6 days following experimental infection. (a) Normal adult with embryos in the uterus, recovered from a control rat which had received nonirradiated infected muscle; (b) adult showing undeveloped embryos in the uterus recovered from a rat which had received infected meat irradiated for 96 hr; (c) adult recovered from a rat which had received meat irradiated for 144 hr showing abnormality in the shape of the body wall.

larvae develop and reach maturity in the intestinal tract of the host 2–3 days following ingestion of infected meat. On the fifth or sixth day about 99 to 100% of the female worms show embryos in the uterus (Fig. 1a). These embryos are liberated into the lymph spaces of the host's intestines and eventually reach the musculature where they become infective in less than 3 weeks.

The method used in these experiments consisted in preparing small cellophane wrappings each enclosing about 1 g of trichinous rat meat and placing the packets between two tubes containing radioactive cobalt, in a refrigerator at about 4° C. The dose of irradiation received by the meat was estimated to be 2000 r for each 24 hr, consisting largely of gamma rays, the beta rays having been filtered out. After the meat was irradiated for a specified interval of time, the contents of each of two wrappings were fed to each of two white rats.[1] One of the rats was killed 6 days after infection to determine the condition of the adult worms in the intestinal tract. The second rat was killed 30 days after infection to determine presence or absence of encysted trichinae larvae in the musculature; if larvae were not found by use of the press preparation method, the muscle was artificially digested and examined. A control rat receiving un-

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