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This article has been collated in response to a series of

dialogues between members of AIM Social Scientific

and Medical Council and The International Scientific

Forum on Alcohol Research. Gordon Troup of Monash

University, invited his mathematician colleague,

Mike Deakin to look at the maths and statistics in the

literature regarding the rate of metabolism of alcohol

and blood alcohol concentration, much of which

dates mainly from the 1950’s and indeed back to the

19th century.

The mechanisms of how alcohol is broken down

We know that alcohol (ethanol), a small water

soluble molecule, can be absorbed unchanged

along the whole length of the digestive tract and

that absorption takes place rapidly from the stomach

(about 20%), and most rapidly from the small gut

(about 80%).

We know too, that the rate of absorption after

drinking is affected by several factors, such as the

concentration and volume of liquid taken with the

alcohol, whether drinking with or without food, the

rate of gastric emptying and individual variations,

such as ethnicity, height, weight and sex.

After absorption into the blood-stream, alcohol is

distributed quickly throughout the total body water.

Approximately 90% is broken down into carbon

dioxide and water at a steady rate, the remainder is

converted to acetate (harmless) – and then into CO_2,

H_2O and energy (this is known as the Krebs cycle) and

excreted via the normal routes!

Myths and realities – can you speed up the rate of

metabolising alcohol?

An interesting study in 1972 by G PAWAN (Metabolism

of alcohol (ethanol) in man Proc. Nutr. Sac. (197z),

31, 83) investigated claims that taking vitamins and

sugars can increase the rate of ‘sobering up’ in man

and laboratory animals. He analysed the effects of

caffeine and strong black coffee, dietary factors,

physical exercise, environmental temperature

changes, thyroid hormones, oxygen therapy and

various drugs on the rate of metabolising alcohol in

humans.

Physical exercise - Despite the increased pulmonary

ventilation, sweat loss and general rise in metabolic

rate, physical exercise did not significantly affect the

rate of alcohol metabolism.

Vitamin supplements - It was concluded that in

these normal, well-nourished individuals, vitamin

supplementation did not affect the rate of alcohol

metabolism.

Caffeine and strong black coffee - Caffeine (50mg)

and two cups of strong, unsweetened black coffee

were given one hour after the dose of alcohol; no

effect on the rate of alcohol metabolism was seen.

The metabolism of alcohol and its effect on estimating blood alcohol

concentration

excreted unchanged in the

urine, expired air and sweat.

The main site of metabolism of

ethanol is the liver, although

some other tissues, for

example kidney, muscle, lung,

intestine and possibly even the

brain, may break down smaller

quantities. It is thought that

the rate-limiting step in the

breakdown of alcohol is its

conversion to acetaldehyde

(toxic), a reaction catalysed by

the zinc-containing enzyme,

alcohol dehydrogenase

(ADH).

The acetaldehyde formed in

the first oxidative step in the

metabolism of ethanol, is then

Metabolism of ethanol

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Significantly, Pawan found that both a long term high fat diet and a starvation diet slowed the bodies ability to break down alcohol by 20%. This was believed to be due to a depletion of enzymes (being inhibited by free fatty acids) and an enhancement of the reduced redox state of liver cells. However, eating a balanced meal before, during or even after drinking does help the metabolism of alcohol. Food, and particularly carbohydrate, retards absorption and blood concentrations may not reach a quarter of those achieved on an empty stomach.

An interesting study by Dr Wayne Jones et al

explored food-induced increase in the rate of

disposal of ethanol. Ten healthy subjects ate a meal

5 hours after drinking when the post-absorbtive

phase of ethanol metabolism was well established.

The mean rate of disappearance of alcohol from the

blood was increased by between 36 and 50%. The

results demonstrate that eating a meal boosts the

rate of disappearance of ethanol from the blood,

and the increase was seen after 3 different doses

of alcohol. (Jones AW, Jönsson KÅ. Food-induced

lowering of blood-ethanol profiles and increased

rate of elimination immediately after a meal. Journal

of Forensic Sciences 1994;39:1084-93).

No sugars, with the exception of fructose, affected

the rate of metabolism of alcohol.

Women

Responsible drinking guidelines are lower for women

for good biological reasons.Very little alcohol enters

fat because of fat’s poor solubility. Blood and tissue

concentrations are therefore higher in women, who

have more subcutaneous fat and a smaller blood

volume, than men, even when the amount of alcohol

consumed is adjusted for body weight. Women

also may have lower levels of the enzymes alcohol

dehydrogenases (ADH) in the stomach than men, so

that less alcohol is metabolised before absorption.

Populations lacking gene to metabolise alcohol

As explained, alcohol metabolism, is catalysed by an

enzyme, acetaldehyde dehydrogenase (ADH). This

enzyme converts acetaldehyde to acetate, which

is a normal metabolite in humans and hence is non

toxic.

Certain individuals, common in the Japanense

and some other Asians, have a defective aldehyde

dehydrogenase gene, ALDH2, which doesn’t

metabolise acetaldehyde as rapidly as normal. Thus,

a person who drinks too much builds up acetaldehyde

in their system and feels bad or is sick. This manifests

in Asians with the defected ALDH gene as a facial

flush as they drink. These responses make drinking

any alcohol unpleasant, as well as toxic.

Comments of Mike Deakin School of Mathematics

Monash University, Victoria 3800 Australia

One would think it a relatively simple matter to

discover the rates of alcohol clearance from the

human body, and in a sense this is the case. However,

if one looks for reputable sources backed up by wellconducted

experiments, then the search suddenly

becomes more difficult!

However, the book Drink, Drugs and Driving by

H. J. Walls and A. R. Brownlie, 2nd Ed. (London &

Edinburgh: Sweet & Maxwell, 1985) is accessible and

authoritative. The first author is a former director of

the Metropolitan Police Forensic Science Laboratory

(UK) and the second a solicitor of the Edinburgh

Supreme Court.

Sensibly, these authors do not try elaborate

mathematical modeling or fancy curve-fits. Rather

they supply 2 straight-lines that summarise the data

excellently well. The rule is this:

For a BAC of 0.15 or greater, the elimination rate is 0.02

per hour, for lower BACs, 0.015 per hour.

Although this source is authoritative and commands

respect, it is not primary, but rather draws on two

other sources,

The rule just given is based on data from a German

study: Gerchow & Steigleder's Blutalkohol (1961); it

is partially supported by an English study ("Effect of

small doses on a skill resembling driving", Medical

Research Council Memorandum No. 38, HMSO,

London, 1959). (This source considers only lower

levels of BAC, but agrees with the figure of 0.015. It

should, of course, be borne in mind that the figures

given are averages only.

The two editions of Walls and Brownlie’s book differ in

some places, and the first edition includes references

not cited in the second. Regrettably, most of these

are likewise difficult of access.

Blood Alcohol Content Metabolised at 0.01 per

Hour?

Comments by Gordon Troup School of Physics,

Monash University, Victoria 3800 Australia

The difficulties in finding satisfactory articles were

great, and there were difficulties even in the articles.

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An article by in ‘Nature’ by Jacobsen [1] in1952 refers

to work by Mellanby (1919) and Widmark (1922-35),

To quote from Jacobsen: “Both studies found in man

an average of 15 mgm. percent alcohol disappears

from the blood per hour, the range being 10-20 mgm.

per cent.”

So we now know when respectable work started!

Again, to be brief as to respectable work and its

interpretation, the best reference in English is by

Walls and Brownlie (1985) [2].We give a reference in

German, by Ebbel and Schleyer (1956).

Since the respectable works agree on the .015 rate of

recovery, to work on a .01 rate seems a good margin of

safety for people to to judge by. Remember, This is for

MEN. If necessary, experts could re-examine the old

references with regard to methods and conclusions

in the light of modern techniques and analytical

developments. In the meantime, it is suggested that

we continue with the .01 rate.

Lynn Gretkowski MD comments

‘Regardless of citations this “clearance number” is

merely now only a number that is generalisable. The

individual pharmacodynamics of alcohol elimination

take into account liver weight, gender, ethnicity, type

and density of alcohol dehydrogenase receptors,

rate at which alcohol is consumed, associated

consumption of food and activities among many

other factors. The reason no new calculations exist

from the mid-nineteenth century onward is likely

largely a reflection of that. It seems as though this is

about as specific as it can be to be clinically useful'.

Dr Erik Skovenborg finds that

'Very little has been added to the Widmark formula

during the years. One aspect, however, investigated

by a pupil of Widmark has found inter individual

variations in the ethanol metabolism: (Jones AW.

Interindividual variations in the disposition and

metabolism of ethanol in healthy men. Alcohol

1984;1:385-91)'.

Dr David Van Velden cited:

‘The ABC of alcohol was published in the BMJ Volume

330, 8 January 2005 (bmj.com). The 4th edition of the

ABC of Alcohol, became available in February 2005.

According to this article alcohol is removed from

the blood at a rate of about 3.3 mmol/hour (15 mg/

100ml/hour)’.

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maximum descends in a straight line to the abscissa: the rate of

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body)

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of alcohol in blood)

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