

## The Pharmacokinetics of Alcohol – Part II

### How Is Alcohol Distributed Throughout The Body and How Does It Get To The Brain?

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Part I discussed the principles involved with the absorption of alcohol into the circulating blood. In this monograph, the principles of how alcohol is distributed throughout the body will be discussed. The principles common to both absorption and distribution are:

1. alcohol will always diffuse from areas of high alcohol concentration to areas of low concentration until a concentration equilibrium is established
2. the blood alcohol concentration at any given time is the net effect of the amount of alcohol absorbed into the blood, the amount of alcohol distributed to the surrounding watery tissues, and the amount of alcohol eliminated from the body
3. alcohol is readily distributed in watery tissues.

Once alcohol is absorbed into the venous blood (as a general rule of thumb, venous blood is the blood returning to the heart; arterial blood is the blood being pumped away from the heart to the extremities of the body) it is circulated to the liver where a fixed number of the enzyme alcohol dehydrogenase (ADH) will metabolize alcohol to carbon dioxide and water. If there are more molecules of alcohol passing through the liver than the enzymes can metabolize, the excess alcohol is then circulated back to the heart where it is then pumped to the lungs and then back to the heart where it is then pumped to the rest of the body.

The principle function of the lungs is gas exchange. Oxygen is inhaled and exchanged for toxic gases in the body that are exhaled on the breath. The most common exchange is oxygen for carbon dioxide, but if alcohol is present in the blood, some will also be blown off in the breath, and hence the underlying principle for breath alcohol testing.

Oxygenated blood is returned to the heart where it is pumped through the arteries to the extremities of the body - the arms, the legs, the head and the torso. The thickness of arteries does not allow for alcohol to leave the arterial blood as it passes through the body. The arteries subdivide into smaller and smaller blood vessels, the smallest of which are the capillary vessels. An exchange of alcohol between capillary blood and the surrounding watery tissues occurs until there is an equilibrium established between the concentration of alcohol in the blood and the concentration of alcohol in the surrounding watery tissues. Capillary blood is subsequently collected in increasingly larger blood vessels and returned to the heart via the venous network of veins as venous blood.

The distribution of alcohol into the tissues of the body depends upon the water content of the tissues and how well supplied the tissue is with blood. The brain, for example, is richly supplied with blood vessels. Fatty tissue tends not to be as well supplied. The brain has significantly greater water content than fatty tissue. It is therefore not surprising that more alcohol will be distributed in brain tissue than in fatty tissue. In fact, just over 60

times more alcohol will be distributed in brain tissue than in fat tissue. The comparison between the concentration of alcohol in blood and the concentration of alcohol in a particular tissue is referred to as a distribution ratio. The following chart shows some of the distribution ratios for various tissues in the body.

TISSUE	MEAN DISTRIBUTION RATIO
Whole Blood	1.0
Fat	0.019
Brain	1.2
Liver	0.9
Urine	1.4
Blood Clot	0.8
Vitreous Humor	1.2

For urine, the distribution ratio is for urine at the point of manufacture within the kidneys, not when it reaches the bladder. If the blood alcohol concentration is rising, as during active absorption, then urine produced by the kidneys will have a higher alcohol concentration than urine in the bladder that it will be pooled with. Conversely, if the blood alcohol concentration is declining, urine resident in the bladder will have a higher alcohol concentration than urine currently being produced. It for this reason that urine samples are not necessarily a reliable indicator of the magnitude of intoxication.

Vitreous humor is a jelly like watery tissue that fills the eye ball and is an excellent post mortem sample for alcohol analysis. It is relatively immune to putrefaction, is readily obtained without the need for a full autopsy, and is the biological sample of choice when the body has been subject to fire or severe trauma such as in a motor vehicle collision.

Because of the blood brain barrier, not all chemicals circulating in the blood can gain access to the brain. The chemical nature of ethanol is such that it is described as bi polar; that is, it is both lipid soluble and water-soluble. Being lipid soluble, it readily diffuses across the blood brain barrier, and being water soluble, it is readily distributed in the watery tissues of the brain. Alcohol's greatest effect is on brain function (the central nervous system) although it also has localized effects on the motility of the stomach and gastric secretions, the production of urine within the kidneys, as well as some depressant effect on bone marrow leading to anemias and folic acid utilization resulting in a decreased response to infections.

Bruce D. Miller is a Pharmacologist specializing in forensic toxicology and more specifically in the effects of alcohol on human behaviour and performance. He has appeared as an expert witness in all of the trial division of British Columbia, Alberta, Saskatchewan, The Yukon Territories, Northwest Territories and Nunavit. He has conducted in excess of 30,000 breath alcohol tests, and has the world's largest data bank of human alcohol pharmacokinetic data.