Alcohol and its Effects on the Brain

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Fifteen million people in America today struggle with alcoholism.[1] Scientists understand that alcohol affects the way our brain works by damaging our frontal lobe, the part of our brain associated with memory, problem solving, and motor control.[1] What scientists are still hypothesizing about is how exactly alcohol damages the frontal lobe, how adolescents are at an increased risk of Alcohol Use Disorder (AUD) than adults, and how other diseases are linked to alcohol. The aim of this paper is: How does alcohol affect the nervous system on both a short-term and long-term level? The goal of this paper is to study and analyze alcohol's effects on the brain in order to demonstrate the risks of consuming alcohol. This paper will review current literature on the nervous system, the neurotransmitter Gamma-aminobutyric acid (GABA), alcohol, and the health effects of alcohol on the brain, and from this conclude that alcohol's risks outweigh its benefits.

The Nervous System and GABA

The nervous system contains two subsystems: the central nervous system, consisting of the brain and spinal cord, and the peripheral nervous system, consisting of the nerves. Communication occurs between the central and peripheral nervous systems by transferring electrical signals between the brain and nerves of the body. Therefore if alcohol impairs the brain, it could potentially lead to nerve damage which is called alcoholic neuropathy.[2] In addition, the brain has many different parts, such as the frontal lobe, temporal lobe, parietal lobe, occipital lobe, cerebellum, and spinal cord. The cerebellum's functions are mostly related to balance and voluntary movements, but new studies are uncovering that the cerebellum has links to addiction. The parietal lobe mostly helps us with understanding the world around us, how we interact with space, and pain. The occipital lobe is strictly concerned with the brain's receiving of information from the eyes. The temporal lobe helps with speaking, short-term memory, understanding rhythm, and our olfactory senses. The frontal lobe does the heavy lifting and is larger than the other parts of the brain, containing your personality, speech, memory, problem solving and decision-making processes.[3] The brain consists of 86 billion nerve cells, called neurons, that communicate with each other via electrical signals. These signals are called action potentials. The neurons consist of a cell body (soma), dendrites that receive signals from other neurons, and the axon which sends signals to other neurons.The space between two neurons where signals are exchanged is called the synaptic cleft (synapse). Within the brain are neurons which fire action potentials that are electrical signals that help the brain function and activate receptors

on other neurons. Neurotransmitters are the chemical signals that are passed across a synapse between neurons, and are essential for the development of a human and everyday function, whereas receptors receive these chemical signals on other neurons. GABA is an amino acid neurotransmitter that helps to inhibit the activity in our brain by slowing it down and blocking specific signals in your central nervous system. Inhibition is an important part of regular brain functioning. Research has shown that low levels of GABA are associated with mental disorders such as schizophrenia and clinical depression, along with general feelings of anxiety.[3] When alcohol is ingested, it actually halts the production of the GABA neurotransmitter and even causes GABA withdrawal, preventing normal brain functions from occurring.[4] This may also be why people who drink alcohol on a daily basis tend to feel a lot more stressed and upset because the alcohol has reduced the amount of GABA inhibiting their brain activity.

Chemical Composition of Alcohol

Alcohol is a chemical compound mostly composed of ethanol (C_2H_6O) and water and is produced through ethanol fermentation. However, it also contains carbonyl compounds (a molecule where carbon and oxygen share a double bond), volatile acids (carbonic acids), hydroxy and oxo acids, fixed acids (all acids produced in the body other than carbonic acid), esters (hydrogens bonded to acidic hydroxyls and organyls), nitrogen compounds, and aromatic compounds (compounds in ring shape and with a distinct smell).[5] It is important to note that ethanol along with these acids is incredibly damaging to the body. The release of serotonin (a mood regulator) and dopamine (a reward system regulator), though, are what affect the frontal lobe and cause permanent brain damage. While these neurotransmitters are crucial for the brain to function, alcohol consumption can lead to overproduction of these two chemicals. Increase in dopamine often results in aggressive behaviors while the increase in serotonin can result in seizures. An excessive increase in dopamine can cause subliminal intoxication, euphoria, excitement, confusion, stupor, coma or in some cases death.[6]

Long and Short Term Effects of Alcohol

Long-term alcohol abuse can lead to increased risk of cancer, brain damage, and Wernicke-Korsakoff Syndrome–a neurological disorder that causes confusion, lack of energy, tremors and memory loss.[7] Wernicke-Korsakoff Syndrome consists of an initial phase and a chronic phase. The initial phase is Wernicke's Encephalopathy, which is commonly associated with confusion, instability, and unusual eye movements. The chronic phase is Korsakoff's Psychosis, where one may have memory problems, hallucinations, and repetitive behaviors usually due to its effect on the hippocampus, the memory-storing area of our brain. Also, because alcohol affects the motor-control part of the brain, movement is impaired when intoxicated, as well as speech and memory.

Some of the short-term effects stem from what we call hangovers. Hangovers that come from excessive drinking can result in physical side effects such as fatigue, headache, increased sensitivity to light and sound, redness in the eyes, muscle aches and thirst. Some of the mental effects are dizziness, mood disturbances, depression, anxiety, and irritability. In addition, the body may experience an increase in systolic blood pressure, rapid heartbeat, tremor, and sweating.[8] This is because alcohol slows down the mental processes in your brain. Neuroplastic changes (the way your brain creates new patterns and routines) can also make it difficult for the brain to recover from alcohol addiction because it cannot easily establish new behavioral patterns. This is especially true for teens because at this age teens' brains have high neural plasticity and can more easily be affected by alcohol, AUD, and are prone to risky behaviors.

Other short term effects of alcohol include slurred speech, drowsiness, vomiting, diarrhea, upset stomach, headaches, breathing difficulties, distorted vision and hearing, impaired judgment, decreased perception and coordination, unconsciousness, anemia (not enough red cells), coma, and blackouts. Depending on one's tolerance of alcohol, the increase in GABA due to alcohol consumption may impair muscle memory and motor control. These impairments thus explain the slurred speech, breathing difficulties, and decreased perception and coordination associated with alcohol use. One may also experience unintentional injuries. If an individual's Blood Alcohol Concentration (BAC) reaches above 0.2% they will begin to experience loss of motor control leading to unintentional falls, car crashes, or drowning.[7]

Genetic Predisposition and Recovery

The most damaging aspect of alcohol is chronic drinking otherwise known as alcohol addiction. It occurs because our body gets addicted to the dopamine release in our brain, which makes us feel good. Naturally, as one gets addicted to alcohol, they will be more and more dependent on it for their source of dopamine. However, while alcohol can make you feel good it can also lead to depression. In addition, chronic drinking will actually deplete the amount of dopamine in your brain over time, which downregulates production of dopamine because it is overproduced when drunk. This is what lays the foundation for an alcohol craving that becomes a lifelong alcohol addiction. So even if you receive a dopamine boost, you will still end up feeling terrible because of mood disturbances caused by the alcohol. It can also result in Alcohol Use Disorder (AUD) which is characterized by constant cravings, avoiding activities, obligations, and family, driving, and knowingly continuing to consume alcohol while understanding its negative health effects. AUD will also worsen any preexisting medical conditions. Also, alcohol can affect certain people more than others due to alcohol tolerance. Generally, the more mass a person has, the more alcohol it will take for them to become intoxicated. However, a group of enzymes called *alcohol dehydrogenases* (responsible for the breakdown of alcohol), can vary between

different livers and bloodstreams as well. In addition, diet and patterns of consumption can change the effect alcohol has on the body.[9]

Some people are also genetically predisposed to alcoholism (a constant craving of alcohol). This is usually passed down from generation to generation. In fact, part of the risk of alcoholism is caused by the genes you carry. However, this does not mean that because previous family members have suffered from alcoholism their offspring will succumb to alcoholism. Other people develop higher rates of alcohol metabolism based on their genes, meaning that alcohol will flush through the body faster than normal. The opposite of this is alcohol flush reaction, a response very common in people of Asian descent. This reaction is also referred to as an alcohol "allergy" because the face turns red due to the fact that acetaldehyde (an acid that damages your tissue) is not metabolized efficiently enough. It also makes the person have headaches and is a sign of low alcohol tolerance. Alcoholism can also lead to an increased risk of cancer, most commonly breast and esophageal cancers because of the carcinogens in acetaldehyde.[10]

If you do suffer from alcoholism, there are methods to help you recover from your addiction. Usually this involves behavioral therapy and certain medications like naltrexone, disulfiram, and acamprosate that help rebalance chemicals in the brain affected by drinking.[11] These behavioral therapies can range from short courses to long term groups. In addition there are different types of behavioral therapy such as cognitive-behavioral therapy, motivational enhancement therapy, marital and family counseling, and brief interventions. Cognitive-behavioral therapy talks through the problems of why someone drinks alcohol and the stresses that may lead to relapses. Motivational enhancement therapy is short and discusses the pros and cons of drinking, creating a plan to change, increasing confidence, and working on skills to prevent relapse. Marital and family counseling is therapy involving a spouse or other family members and repairing relationships due to alcohol. This type of therapy has been seen to work better than others since a family member is there to support you and hold you accountable. Brief interventions are short one-on-one meetings with a therapist who will ask about drinking habits and create a plan for you to slowly stop drinking.

How Alcohol Works with Other Diseases and Binge Drinking

Other risks of excessive alcohol consumption include liver disease, high blood pressure, stroke, heart disease, digestive problems, cancer, weakening of immune system, mental health problems, and learning and memory problems. In addition, preterm births are more likely in pregnant women who drink regularly.[10] When too much alcohol is ingested, the liver cannot handle filtering all the alcohol through the body and becomes damaged, possibly leading to cirrhosis in which the eyes and skin jaundice. Excessive alcohol consumption also affects the heart, veins, and arteries because of how alcohol travels through the bloodstream. Twenty

percent of the alcohol you drink enters your bloodstream through your stomach, while the rest enters through the small intestine.[12] This is why alcohol seems to fill your stomach like a meal would, however too much alcohol could result in malnutrition. Drinking alcohol can harm your stomach as well, leading to more drinking, overeating, digestion problems, and stomach ulcers because when the gastric juices in your stomach mix with alcohol it irritates the stomach lining.

There are different classifications for alcohol addiction. Binge drinking is when a person is drinking excessively on back-to-back days. For women it is considered binge drinking when you drink 4 or more drinks, and for men it is 5 or more drinks. Heavy drinking mostly classifies those who drink many times a week. You are considered a heavy drinker as a woman if you have 8 or more drinks a week and 15 or more drinks for a man. The reason that men have a higher alcohol tolerance than women is because men have more of the enzyme dehydrogenase, which breaks down alcohol. While these numbers are true for most people, those who feel the effects of alcohol more quickly on their system should not drink even the regular amounts as motor control and vomiting problems will ensue. Some people may get sick from alcohol even if they are a chronic alcoholic, and this might be because of the quality of the alcohol itself. It has been shown that high levels of methanol, acetaldehyde, ethyl carbamate, or coumarin may even be lethal. In fact, even if you drink good quality alcohol but have a BAC level between 0.31-0.45% you could get alcohol poisoning, usually caused by binge drinking. This is because of acetaldehyde (which comes from oxidizing ethanol) and acetic acid, two toxins which your body wants to get rid of but cannot if you consume too high of an amount. This could result in a loss of consciousness or even death if your BAC reaches too high of a percentage. So, it is important to know how much alcohol you can handle and what alcohol you are drinking.[7]

Alcohol withdrawal (when someone suddenly stops drinking as a chronic drinker) may also induce problems for some people. When going through withdrawal, excitatory components of the brain called glutamate neurotransmitters begin to overload after being inhibited for a long time because of the methanol in alcohol.[8] Certain characteristics are epileptic seizures. This is because heavy drinkers may experience cerebral atrophy (meaning the brain has lost nerve cells and connections to the brain tissue) which will in turn make these drinkers more prone to seizures. Increased intake of alcohol will also diminish the effects of epileptic drugs. In addition, withdrawal may lead to nausea, vomiting, headache, auditory disturbances, agitation, paroxysmal sweating, visual disturbances, tremor, clouding of sensorium, orientation, and anxiety. In terms of recovery or assistance with withdrawal, patients need intravenous rehydration, correction of electrolyte abnormalities, and must have no comorbid conditions. In order to reduce the risk of having a comorbid condition patients are given a “banana bag” which contains folate, thiamine, dextrose, and multivitamins. However, the most helpful drug is benzodiazepines, typically lorazepam or diazepam because they can slow down brain activity affected by alcohol. An increase in dosage of these drugs may be needed to treat severe alcohol withdrawal.

Staying Safe When Drinking

When consuming alcohol, it is crucial to take several precautions to ensure safety and that you are responsibly drinking. First, be aware of your own alcohol tolerance and limits, as these vary from person to person based on factors like body weight, metabolism, and overall health. Always pace yourself and know when to stop drinking to avoid overconsumption. Drinking on a full stomach can slow the absorption of alcohol, reducing its effects. It's also a good idea to designate a sober driver or arrange alternative transportation (like an Uber or Lyft) when planning to consume alcohol away from home to prevent drunk driving incidents. As DUIs consist of 29% of all traffic related incidents it is important you do this.[13] In addition, staying hydrated by drinking water between alcoholic beverages helps mitigate the dehydrating effects of alcohol and can lessen the severity of a hangover. Finally, being mindful of mixing alcohol with medications or other substances, as this can have unpredictable and dangerous consequences. Responsible alcohol consumption involves understanding your own limits, knowing when to say no, and looking out for the well-being of yourself and others.

Discussion & Conclusion

Overall, the overconsumption of alcohol and its effects on the brain is incredibly damaging. While drinking can be safe, excessive consumption of alcohol can lead to many other unhealthy habits or diseases. It is also important to understand that when you are intoxicated, you are very vulnerable because the alcohol has brought down your natural defenses such as motor control and good judgment skills. Alcoholism is also a very hard addiction to break, and while therapies can help, the long lasting effects on physical and mental health on an alcoholic are irreparable. In addition to this, alcohol withdrawal can be very bad especially for those who are heavy drinkers, and in some cases can even lead to death.

Also, the idea that people drink alcohol just for “fun” and to be happy is not always true. Alcohol has been proven to increase depression and exacerbate your mood when intoxicated. It also forces your brain to overproduce dopamine, which in turn gives you a huge mental boost. But, the more one drinks the more that dopamine will decrease eventually causing a downregulation in dopamine. In response to this, chronic alcoholics find themselves in a vicious cycle of trying to chase down the initial dopamine rush but only diminishing it by doing so.

Another piece of evidence as to how alcohol can harm someone is its association to other diseases, especially cardiovascular and liver diseases as alcohol passes through these systems the most. Even though alcohol may feel like a relief from these diseases it will only make them worse or cause them in the first place. It is also important that one understands exactly what they are drinking, as some alcohol (if not produced right) may have lethal

concentrations of certain chemicals, mainly methanol which is so toxic that it may lead to dizziness, blindness, or death.

In conclusion, the harm far outweighs the benefit when it comes to consuming alcohol. Risking addiction, disease, family trouble, or death just for a few drinks each day is a mistake. It must be understood that alcohol should only be drunk in moderation and the person who is drinking it must understand their own tolerance, what is in the drink itself and who gave it to them. Therefore, people should strive to dispel myths surrounding alcohol and promote informed and safe choices on the dangers of drinking or relying on alcohol.

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