Alcohol and Drugs 15

This chapter is about the synergistic effects of alcohol and drugs. These effects are highlighted with examples of several case studies. Synergism is the capacity of two or more drugs acting together so that the total effect of these drugs is greater than the sum of the two drugs acting alone and independently. These cases are about interaction of alcohol and prescription as well as over-the-counter medications. Doctors and pharmacies instruct patients not to drink alcohol when on certain medications. For example, drugs that affect or suppress the CNS should not be used simultaneously with alcohol. This simultaneous use can cause a synergistic reaction leading to fatal consequences (**1-3**).

15.1 DUI, Injured Cyclist

15.1.1 Legal Aspects: DUI and Injured Cyclist

This report deals with an accident involving a 14-year-old boy, Billy Bella, who was hit by a pickup truck while he was riding his bike. The accident resulted in serious injuries and fractures to the cyclist. The pickup truck was driven by David Palmer, of Palmer Constructions, Inc. The police arrested Mr. Palmer for presumptive DUI. The family of the cyclist, Billy Bella, brought a civil lawsuit against Mr. Palmer and Palmer Construction Company for monetary compensation for pain and suffering of the cyclist. Mr. Palmer admits drinking alcohol while he was on prescription medications.

15.1.2 Medical Aspects: Alcohol and Synergistic Effect of Prescription Medications

Alcohol is metabolized by the liver and the synergistic effects of prescription medications on alcohol intoxication are well known. For this reason, patients on certain prescription medications are advised not to drink alcohol.

15.1.3 Factual Background

This report deals with an accident involving a 14-year-old bicyclist and a pickup truck. The accident happened on July 24, 2005, resulting in serious injuries to the bicyclist.

Billy Bella is a Caucasian male, 14 years of age, living at home with his parents Robert and Susan. He was attending Taylor High School and completed 9th grade. He was on summer vacation. On July 24, 2005, he was riding his bicycle with his family friend Joseph, who also was riding his bicycle. Billy was wearing a helmet. At approximately 3:00 p.m., both boys were riding their bikes in the parking lot at 35 Sawmill Run Road, Wellwood, Karentakey. This parking lot connects to a bike path, which connects with a small wooden bridge. It was a clear, sunny day. David Palmer was driving a Red Dodge Ram pickup truck. The pickup truck first backed up into a parking space and then came forward. The driver's side of the bumper of the truck hit the front tire of Billy's bicycle and his left knee. Billy fell down on his back and was in intense pain. His friend Joseph saw it happen. Billy was bleeding. Joseph and David Palmer put Billy in the pickup truck and drove him home. Mr. Palmer told Billy's parents that he felt sorry for the accident. The police came to Billy's house and spoke to Billy's parents. An ambulance was called in, which took Billy to Sanjeev Hospital emergency room.

The accident resulted in serious injuries and health consequences to Billy requiring hospitalization and physical therapy. His knee was fractured and the orthopedic doctor gave him a knee immobilizer. He was confined to home for eight weeks. Because of the injuries to his back, he developed an infection, which required a visit to the emergency room and treatment at the hospital. This disabled Billy for several weeks.

David Palmer is a Caucasian male, 44 years of age, 5 feet 10 inches tall and weighing approximately 175 pounds. He is the president of Palmer Construction. He admitted to the police that he is on prescription medications, which included Wellbutrin for depression, Altace for high blood pressure, and Asacol for ulcerative colitis. He took all these medicines in the morning with breakfast. The dosages of these medications were not given. In his testimony, Mr. Palmer said that he had breakfast that day and started working at 8:30 a.m. He had a chicken salad sandwich for lunch at 12:00 p.m. He also had a snack in the afternoon. He admitted purchasing a bottle of white wine. He said that he consumed approximately 1½ glasses of white wine starting with his lunch. However, according to the testimony of Billy's parents, they said that Mr. Palmer smelled of alcohol and was drunk when he was at their house. The police assured them that they would investigate. The police also told them that Mr. Palmer admitted drinking two or three glasses of wine. The police gave Mr. Palmer field sobriety tests but no Breathalyzer test. No police intoxication report was available.

15.1.4 Alcohol, Medications, and Cognitive Functions

Alcohol and several medications alone or in combination impair cognitive functions. Ethanol, also called ethyl alcohol or alcohol, is a water-soluble

compound, and readily distributes into several body compartments including the brain. BAC correlates well with the alcohol levels reaching the brain, which reflect the level of alcohol intoxication. As stated previously, BAC depends upon several factors (**3-11**). Patients are advised not to consume alcohol when they are on certain prescription medications. Mr. Palmer is an educated person; he has a 4-year college degree. Yet, he was irresponsible in drinking alcohol while taking Wellbutrin, Altace, and Asacol.

15.1.4.1 Wellbutrin

Wellbutrin is prescribed for depression. This drug is also known as bupropion. It has a half-life of 4 to 24 hours. It is protein bound in plasma and remains in circulation for a long time (**7**). This medication has side effects and can make a person drowsy and dizzy. Alcohol may make the side effects of this drug worse. This drug clearly interacts with alcohol and may interfere with its clearance (**6-8**). In fact, there is a published case report that showed the combination of bupropion and alcohol resulted in a fatality (**8**). People taking this drug are asked to operate motor vehicles and machinery with caution. Patients taking this medication are asked not to drink alcohol (**6-8**).

Altace is prescribed for high blood pressure. Side effects include drowsiness and dizziness. Patients taking this drug should avoid alcohol because it could further lower blood pressure and increase drowsiness or dizziness (**7,8**).

15.1.5 Alcohol Intoxication

Based on Mr. Palmer's testimony, he bought a bottle of white wine and drank 1½ glasses. According to Billy's parents, the police told them that Mr. Palmer admitted drinking 2 to 3 glasses of wine. Since he had lunch and was snacking in the afternoon, there was food in his stomach. In addition to the food in the stomach, the medication with a long half-life delays alcohol clearance. Mr. Palmer weighed 175 pounds. It is assumed that he drank two 8-oz. glasses of wine. White wine is assumed to have 15% alcohol content. Based on these assumptions, it is possible to calculate Mr. Palmer's BAC at the time of the accident.

It is scientifically accepted that a 150-pound man will have a BAC of 0.025% after drinking 1 oz. of 50% alcohol (**6**). Given this assumption, which is accurate under almost all circumstances, the BAC of Mr. Palmer can be calculated as follows:

$$\text{BAC} = 150 \div \text{Body weight} \times \%\ \text{ethanol content} \div 50 \times \text{ounces consumed} \times 0.025$$

$$\text{BAC of Mr. Palmer} = 150 \div 175 \times 15 \div 50 \times 16 \times 0.025 = 0.10\%$$

Based on these calculations, Mr. Palmer's BAC was 0.1% at the time of the accident, which was above the legal limit of 0.08% in the state of Karentakey. He was intoxicated with alcohol even without taking into consideration the synergistic effects of Wellbutrin and Altace. At this BAC, a person experiences impairment of sensory-motor activities, reaction times, attention, visual acuity, and judgment. The individual may still appear sober (**3**).

15.1.6 Conclusions

Based on the available evidence, it can be concluded with a reasonable degree of medical and scientific certainty that:

1. Mr. Palmer drank alcohol while on prescription medications even though he was fully aware that the combination of alcohol and his medications would seriously impair his cognitive functions.
2. Mr. Palmer was intoxicated and was unfit to drive and operate his pickup truck at the time of the accident.
3. Mr. Palmer bears full responsibility for the accident.
4. The accident caused serious trauma and injuries to Billy Bella resulting in his pain and suffering and his disability for a considerable amount of time.

15.2 Presumptive DUI, Drug Synergistic Toxicity

15.2.1 Legal Aspects: Presumptive DUI and Possession of a Controlled Substance

This case is about Mr. Aaron Asky, who was stopped by the police and was arrested for presumptive DUI and possession of controlled substances. The police officer searched and found in the pockets of the defendant five small green pills and four white rocks, which were presumed to be crack cocaine. The green pills were identified as Valium. The defendant's BAC was determined to be 0.04% and no cocaine or other drugs of abuse were reported in the serum. Diazepam and nordiazepam levels were in the therapeutic range. He was not charged with DUI but was sentenced for possession of crack cocaine.

15.2.2 Medical Aspects: Synergistic Toxicity of Alcohol and Controlled Substances

The defendant's BAC was only 0.04%, which is considered a subclinical level. He had no cocaine in the serum and his diazepam and nordiazepam levels were in the therapeutic range. This and his BAC cannot cause intoxication.

15.2.3 Factual Background

The defendant, Aaron Asky, is a Caucasian male, 6 feet tall and weighing 210 pounds on October 1, 2004, the day on which he was stopped by the police at approximately 2:30 p.m. and charged with possible DUI and possession of a controlled substance. The defendant was driving a silver Toyota Camry traveling east on Belaware Pike. He worked from 4:00 a.m. to 12:00 p.m. and stopped at his sister's place for pizza and a couple of beers before driving to his home. The police officer stopped the defendant on suspicion that he was driving his vehicle at an excessive rate of speed. According to the officer, the defendant had a mild odor of alcoholic breath. The preliminary breath test (PBT) administered by the officer gave a reading of 0.057%. It appears that the officer, frustrated with the low presumptive BAC, searched the defendant's pockets and found five small green pills. The officer also discovered four white rocks, which were presumed to be crack cocaine. Mr. Asky was subsequently taken to Blue Lagoon Hospital where his blood was drawn at 3:00 p.m. by a hospital technician.

The tubes of blood, the green pills, and the white rock substance obtained from the defendant were submitted for laboratory analysis. State Police Regional Laboratory identified the green pills as diazepam and the white chunky powder to be 0.8 g of cocaine. Mr. Asky's serum was sent to MedScan for quantitation of BAC, which was found to be 41 mg/dL or 0.04%. The serum was also used for immunochemical detection of diazepam and nordiazepam. These two compounds were further quantitated by GC-MS. The serum contained 356 ng/ml of diazepam and 182 ng/ml of nordiazepam. The laboratory could not detect opiates, barbiturates, cocaine, amphetamines, cannabinoids, PCP, or methaqualone by immunochemical assay in serum.

15.2.4 Blood Alcohol Concentration

As stated previously, BAC depends on several factors. In a normal healthy male weighing 200 pounds, one alcoholic drink is expected to give a BAC of 0.02% (**3,10**). In the same individual, alcohol from blood dissipates at a rate of 0.02% per hour (**3**). The defendant's blood was used to measure alcohol by an enzymatic procedure as well as by headspace GC. The result was a BAC of 0.04%.

Blood alcohol levels reflect the levels reaching the brain and this in turn reflects the level of alcohol intoxication. There is a commonsense and scientific presumption that conviction should only occur if the BAC, and subsequently the alcohol reaching the brain, indicates alcohol-induced impairment of driving ability. A BAC between 0.01 to 0.05% is considered sub-clinical and the majority of the population do not have any physical or mental impairment (**3,9**). According to the law in Pennsylvania, the levels are far below the legal limit.

15.2.4.1 Valium (Diazepam)

Diazepam is effective in the management of generalized anxiety disorders and panic disorder. This drug is also used in the treatment of skeletal muscle spasms due to inflammation or trauma. This drug can become addictive (**7,8**). The half-lives of serum diazepam and its metabolite nordiazepam are 21 to 37 hours and 50 to 99 hours, respectively (**7**). The therapeutic serum levels are 0.142 to 1 μg/ml. Based on several studies, peak plasma diazepam levels were determined to be 253 to 568 ng/ml. Peak serum levels occur in 0.5 to 2.5 hours after intake. Benzodiazepines are generally of low order toxicity. Death from overdose ingestion of benzodiazepines alone is extremely rare (**7,12**). According to another study, the therapeutic diazepam serum levels are 0.02 to 4.0 μg/ml and toxic levels are 5 to 20 μg/ml; greater than 30 μg/ml is considered lethal (**7,8**). Based on a standard pharmacology textbook, diazepam can cause CNS depression at 900 to 1000 ng/ml (**12-14**).

The defendant's serum was found to contain 346 ng/ml of diazepam and 182 ng/ml of nordiazepam. These levels are in the therapeutic range and much below toxic levels. Moreover, this drug can cause CNS depression, which can occur only when serum levels are at 0.9 to 1.0 μg/ml (**14,15**). Mr. Askey's benzodiazepine levels were much below the levels to cause CNS depression; therefore, these levels could not cause impairment of his driving abilities.

The defendant's blood alcohol concentration was 0.04%. These levels are considered sub-clinical and are expected not to cause any physical impairment of driving ability. Similarly, the serum levels of diazepam and nordiazepam are within the therapeutic levels and were much below the levels that lead to CNS depression. They were not in the toxic range.

15.2.5 Conclusions

It can be concluded with a reasonable degree of medical and scientific certainty that:

1. The defendant's blood alcohol levels were 0.04%, which is definitely sub-clinical levels and are not expected to cause any alcohol intoxication leading to impairment of driving ability.
2. The serum diazepam and nordiazepam concentrations were at low therapeutic levels and were much below the levels that cause CNS depression.
3. The defendant was not intoxicated with ethanol or with diazepam. He had no impairment whatsoever in his driving ability.

15.3 DUI, Drugs, and Leaving the Scene of an Accident

15.3.1 Legal Aspects: DUI and Drug Interaction

This case is about Ms. Kranti Kensisky, who was arrested for leaving the scene of an accident and on suspicion of presumptive DUI. Kranti contends that she was not aware of the accident and her BAC could not be as high as 0.21 as the state police laboratory analysis suggests. She said that she had only two vodkas with water. She had taken two tablets of ibuprofen and she was on naproxen. The two medications might have affected her BAC.

15.3.2 Medical Aspects: Synergistic Toxicity of Naproxen and Alcohol

Naproxen and consumption of alcoholic drinks have impaired Kranti's judgment with respect to leaving the scene of the accident. Naproxen alone can cause these behavioral abnormalities even at therapeutic doses in some individuals. The combined use of alcohol and naproxen can synergistically further enhance these effects.

15.3.3 Factual Background

Kranti Kensisky is a 50-year-old Caucasian female, weighing 114 pounds on February 23, 1999, the day of the accident and her arrest by the state police for possible DUI. The accident happened at approximately 8:55 p.m. The defendant was driving a Honda Accord 1998, on State Road XY8 toward the intersection with Queens Road. The defendant's vehicle went into the opposite lane, closely missed another vehicle, and struck the driver side of the vehicle driven by Julie Desai. Several motorists witnessed this accident. The defendant left the scene of the accident and drove to a friend's house. The police caught up with her at the friend's house. The police found her with alcoholic breath, confused, and somewhat disoriented. The defendant swayed and her walking was unsure. The defendant admitted that she drank two vodkas and water at Tipps Cove Bar. The police administered a breath alcohol test and estimated her BAC to be 0.21%. The defendant claimed that she was a responsible citizen and insisted that she was not aware of the accident. She stated that the combination of prescribed medication, naproxen, and consumption of alcoholic drinks might have impaired her judgment with regard to leaving the scene of the accident. She also took two tablets of ibuprofen on the day of the accident. She further contends that in no way could she have known about the accident. She was undergoing therapy for neuroma of her right foot.

15.3.4 Blood Alcohol Concentration

BAC depends on several factors as stated previously (**3,11**). People with end-stage liver disease accumulate very high BAC even when they drink non-alcoholic beer (**16**). Medications affecting liver function also tend to increase BAC (**3-11**). In a normal healthy male weighing 200 pounds, one alcoholic drink results in BAC of 0.02%. At the same time, 0.02% of BAC is dissipated from blood in 1 hour (**3**). Since the defendant weighed 114 pounds, one alcoholic drink should result in a BAC of 0.035%. The two drinks she admits she drank should result in a BAC of 0.07%. However, the breath alcohol test administered by the police estimated her BAC to be 0.21%. There are no grounds to challenge the accuracy of this test.

It is most likely that the elevated BAC levels were due to the naproxen she was taking. Patients are warned not to consume alcohol while taking non-steroidal medications like naproxen (**17**). A BAC of 0.21% can cause emotional instability, lack of critical judgment, impairment of memory, and comprehension (**8**). Naproxen alone can cause these behavioral abnormalities even at therapeutic doses in some individuals (**8**). The combined use of alcohol and naproxen can synergistically further enhance these effects.

15.3.4.1 Naproxen

The defendant started taking naproxen three days before the accident. She as well as her physician did not have time to evaluate the adverse effects of this drug. Naproxen is a non-steroidal anti-inflammatory drug that is used to alleviate pain and inflammation **(8)**. This drug is nearly 100% absorbed from the GI tract. The half-life of this drug is 13 hours with a volume of distribution of 0.1L/kg. Naproxen is metabolized mainly by the liver and is excreted through the kidneys. Naproxen was shown to cause hepatotoxicity with alcohol as evidenced by elevation of liver enzymes (**18-20**). Consequently, the Food and Drug Administration has recommended that patients taking naproxen should not drink alcoholic beverages (**17**). Naproxen can also cause adverse reactions even at therapeutic doses in some individuals. These include CNS effects such as dizziness, drowsiness, and vertigo. Naproxen was also shown to cause cognitive dysfunction, such as forgetfulness, inability to concentrate, depression, disorientation, and paranoid ideation (**21,22**).

15.3.5 Conclusions

It can be concluded with a reasonable degree of scientific certainty that:

1. The defendant should not have consumed alcohol when she was on naproxen.

2. Naproxen and alcohol compete for metabolism by the liver and consequently it is not surprising that her BAC was elevated to 0.21% even though she only had two drinks.
3. Combined use of naproxen and alcohol caused synergistic toxicity and resulted in her CNS effects and cognitive dysfunction.
4. It is probable that she was not in a position to comprehend the consequences of her actions when she left the scene of the accident.
5. Naproxen-induced synergistic toxicity combined with alcohol caused these behavioral problems.

15.4 Elevated Blood Alcohol Due to Medications

15.4.1 Legal Aspects: Alcohol and Prescription Medications

This case is about Mr. Meson Geramid, who was stopped by the police on suspicion of presumptive DUI. He was given field sobriety tests, which he failed. He was arrested and his blood was sent for analysis of alcohol. Blood analysis showed that Mr. Geramid had a BAC of 0.16%. Mr. Geramid contends that he drank only two or three shots of vodka and the blood alcohol analysis is flawed.

15.4.2 Medical Aspects: Elevated Blood-Alcohol Due to Prescription Medications

The prescription medications might interact with alcohol metabolism by the liver resulting in falsely elevated blood alcohol levels.

15.4.3 Factual Background

Mr. Meson Geramid is 66 years of age. He is a Caucasian male, 5 feet 8 inches tall and weighing 193 pounds on the day of his arrest for possible DUI. Mr. Geramid has a crocodile farm and exports crocodile meat and skin. He also owns several racehorses. He was driving a 2000 Cadillac Sedan. He was staying at Full Moon Cottage. He drank two or three vodkas that evening. He started drinking at 8:00 p.m., finished his last drink at 9:30 p.m., and then left the cottage immediately. On his way home, he stopped at a restaurant and asked for directions. The people at the restaurant called 911 and alerted them about Mr. Geramid and the car he was driving. According to the police arrest report, Skyloop County 911 alerted the police to look for a dark-colored Cadillac. The police stopped Mr. Geramid and gave him field sobriety tests, which he failed. He was arrested and taken to County Medical Center. Blood was drawn at 11:13 p.m. and the blood alcohol analysis gave a result of

0.16%. Mr. Geramid told the police that he was taking prescription medications daily. He was on 250 mg of Depakote, three times a day, 20 mg capsule of Prozac, once a day, and 5 mg of Norvasc.

15.4.4 Blood Alcohol Concentration

BAC depends upon several factors as previously mentioned. In a normal healthy male weighing 200 pounds, one alcoholic drink gives a BAC of 0.02%. Alcohol in blood is dissipated at a rate of 0.02% in one hour in a normal healthy male (**3,4**). Patients with end-stage liver disease cannot metabolize alcohol and their blood alcohol levels become elevated even if they drink non-alcoholic beer (**16**). Mr. Geramid is on prescription medications and they clearly affected the metabolism of alcohol.

Prozac is an antidepressant and it is essentially metabolized by the liver with a long elimination plasma half-life. Because Prozac may impair judgment, thinking, or motor skills, patients taking this medication are advised not to drive or operate dangerous machinery. Both Prozac and alcohol depress the CNS. Therefore, patients taking this medication are advised not to drink (**5**).

Depakote is metabolized by the liver with a plasma half-life of 9 to 16 hours. Patients taking this medication are advised not to drive a motor vehicle. They are also advised not to drink. Both Depakote and alcohol produce CNS depression. Norvasc is a long-acting calcium channel blocker. It is also completely metabolized by the liver with a long plasma elimination half-life (**8**).

Mr. Geramid was advised not to drive a motor vehicle as Prozac and Depakote can depress the CNS and greatly inhibit his judgment and motor skills. He was also advised not to drink while he is on these medications as alcohol can also cause CNS depression and will inhibit his motor skills and judgment. The prescription medications and alcohol have additive and synergistic effects. They inhibited his judgment and motor skills. Even though Mr. Geramid is accustomed to drinking alcoholic beverages daily, he is not immune to the synergistic effects of prescription medications and alcohol.

Mr. Geramid claims that he drank only two or three vodkas that evening, and his BAC as determined by the hospital approximately 3.5 hours after his first drink was 0.16%. Three vodkas for Mr. Geramid weighing 193 pounds would give a maximum BAC of 0.06%. Mr. Geramid was expected to metabolize 0.02% of alcohol from blood in 1 hour. After a lapse of 3 hours, he was expected to metabolize 0.06%. Therefore, his BAC at 11:13 p.m. should have been 0%. To get 0.16% BAC, Mr. Geramid would have had to consume at least 11 shots of vodka (one shot of vodka, which is 1.5 oz., has same amount of alcohol as in a 12-oz. can of beer with 5% alcohol) between 8:00 p.m. and 9:30 p.m., the time at which he left the cottage. Either he is under-reporting the number of vodkas he consumed or he is not dissipating alcohol from his

blood due to his prescription medications, Prozac and Depakote. These two medications compete with alcohol in its metabolism in liver. Therefore, even with two or three vodkas his BAC could have been artificially elevated, in which case he would show symptoms of intoxication due to the combined and synergistic actions of Prozac, Depakote, and alcohol. This is not surprising because people with end-stage liver disease can reach high BAC even if they drink non-alcoholic beer (**16**). Therefore, Mr. Geramid's BAC was artificially elevated. He is not supposed to drink alcohol or drive a motor vehicle when he is on Prozac and Depakote.

15.4.5 Conclusions

It can be concluded with a reasonable degree of scientific certainty that:

1. Mr. Geramid's BAC of 0.16% is artificially elevated due to his prescription medications.
2. Without these medications, his BAC for three vodkas at 11:13 p.m. should have been 0%.
3. At the time the police stopped him at 9:48 p.m., his BAC should have been 0.03%.
4. He should not have driven his car after he consumed alcohol particularly when he was taking Prozac and Depakote.

15.5 Alcohol and Prescription Medications

15.5.1 Legal Aspects: DUI

This case is about a defendant who was stopped by the police at a DUI checkpoint. His BAC of 0.083% was determined by headspace GC. Since this is just above the legal limit (0.08%), he was arrested for DUI. The defendant says that his BAC cannot be nearly as high as the test results suggest. He says that there must be a mistake in the laboratory analysis based on the number of beers he drank and the time between his last beer and his blood draw.

15.5.2 Medical Aspects: Differences between Calculated and Analytical Values of BAC

It is possible to calculate the expected BAC based on the body weight, the number of drinks consumed and their alcoholic content, and the period in which they were consumed. All methods for blood alcohol measurement are subject to 5 to 10% statistical variation. This is important when the BAC is on the borderline for the legal limit.

15.5.3 Factual Background

Daniel Gilcrist is a 36-year-old Caucasian male. He weighs 280 pounds and is 5 feet 11 inches tall. He attended a Pittsburgh Penguins and Philadelphia Flyers hockey game on September 29, 2007 and drank two 12-oz. Coors Light beers at the game. His first beer at the game was at 7:15 p.m. and he drank the second beer at 9:00 p.m. He also ate a hot dog. He says that he left the game at 10:00 p.m. and went to a tavern with a friend. He had three more 12-oz. cans of Coors Light beer. His third beer was at 11:00 p.m., the fourth beer was at 12:00 a.m., and the fifth beer was at 1:15 a.m. He left the tavern at 2:00 a.m. He was driving a Dodge Dart Sedan and was stopped by the police at a DUI checkpoint at 2:45 a.m. The police reported that Daniel failed field sobriety tests. His blood was drawn at 3:08 a.m. and was sent for blood alcohol analysis to the PAT Forensic Laboratory. The analysis performed by headspace GC gave a BAC of 0.083%.

15.5.4 Blood Alcohol Concentration

Ethanol, also called ethyl alcohol or alcohol, is a water-soluble compound that readily distributes into several body compartments including the brain. BAC reflects the alcohol reaching the brain and this in turn reflects the level of alcohol intoxication. BAC depends on the number of drinks consumed, their alcohol content, and the time frame in which they were consumed. BAC also depends upon the time lapse between the last drink and the time at which the BAC was measured. In addition, BAC depends on body weight, age, gender, health, and use of prescription or over-the-counter medications. It takes between 60 and 90 minutes for alcohol to be completely absorbed from the GI tract and reach peak levels in the blood. In some individuals, this is known to take more than two hours. Food in the stomach is known to delay absorption. Alcohol is metabolized by the liver and is dissipated from the blood at a rate of 0.02 % per hour (**3,4**).

15.5.5 Calculation of BAC

It is scientifically accepted that a 150-pound man will have a BAC of 0.025% after drinking 1 oz. of 100 proof (50%) alcohol. This assumption is accurate under almost all circumstances (**6**). The following equation is used to calculate BAC.

$$\text{BAC} = 150 \div \text{Body weight} \times \%\ \text{ethanol content} \div 50 \times \text{Ounces consumed} \times 0.025$$

Daniel weighed 280 pounds on the day of the incident. He says that he drank Coors Light beer, which has an alcoholic content of 4.2%. He drank 12-oz. cans of beer. Based on this information, his calculated BAC would be as follows:

$$\text{BAC due to 1 beer} = 150 \div 280 \times 4.2 \div 50 \times 12 \times 0.025 = 0.013\%$$

$$\text{BAC due to 5 beers} = 0.065\%$$

Daniel admits drinking five beers. His first beer at the game was at 7:15 p.m., the second beer was at 9:00 p.m., and he had a hot dog at this time. He left the game at 10:00 p.m. and went to a tavern with a friend. His third beer was at 11:00 p.m., the fourth beer was at 12:00 a.m., and the fifth beer was at 1:15 a.m. He left the tavern at 2:00 a.m. His blood draw at the DUI checkpoint was at 3:08 a.m. Thus, there was a time lapse of at least two hours between his last beer and his blood draw. In these two hours, he was expected to dissipate 0.04% of alcohol from his blood. If this were subtracted from 0.065%, his resultant BAC would be 0.025%. The discrepancy between this calculated value and the BAC determined by the GC might be due to the prescription medications. Mr. Gilcrist was taking prescription medications for the past year. The medications include Lexapro, 20 mg/day, Wellbutrin, 100 mg/day, Lasix, 40 mg/day, and Cytomel, 500 μg twice a day. These prescription medications as well as alcohol are metabolized by the liver and they tend to slow down the dissipation of alcohol from blood (**4,13**).

15.5.6 Accuracy and Precision of Blood Alcohol Analysis by Headspace GC

Accuracy and precision are extremely important for blood alcohol determination in a clinical laboratory as well as in a forensic laboratory. Patient management in a clinical setting as well as conviction by law enforcement depends on the blood alcohol result. GC determination of blood alcohol is considered a gold standard, as the method is subjected to very few analytical inferences (**12,23**). Even then, the result is subject to human errors as well as statistical variations. In Pennsylvania, all laboratories are licensed based on their participation in periodic proficiency testing and inspection. The laboratory must analyze the blood alcohol sample spiked with an unknown amount of alcohol sent by the state and obtain results within ±10% of the expected value. In addition, the laboratory must run calibrators and at least two levels of blood controls obtained from outside manufacturers. The results obtained each day for each control are plotted against the spread of the results over the expected target value. These are called Levey-Jennings plots. It is generally accepted that these will vary by ±10 % (**12,24**). Some laboratories may set this

variation at ±5%. At 10% variation, Daniel's BAC could be as low as 0.075% and at 5% variation, his BAC could be 0.079%.

15.5.7 Conclusions

The following conclusions can be arrived at with a reasonable degree of scientific certainty:

1. Based on Daniel's body weight, the number of beers he drank, and the time lapse between the last beer and his blood draw, his calculated BAC is below the legal limit.
2. Daniel's prescription medications slowed down the metabolism of alcohol by the liver resulting in a BAC higher than expected.
3. The blood alcohol levels determined by headspace GC are subjected to ±10% or ±5% statistical variation. Daniel's BAC might be as low as 0.075% at 10% variation or 0.079% at 5% variation.

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