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Analysis of the Prevalence of Medicines and Psychoactive Substances Among Drivers in the Material of the Department of Forensic Medicine at the Medical University of Bialystok

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of article; **G** – other

Abstract

Introduction. In recent years, the issue of drivers under the influence of medicines and psychoactive substances as a cause of collisions and accidents has been more significant.
Objectives. To evaluate the prevalence of medicines and psychoactive substances in the blood of drivers.
Material and Methods. The data, recorded in 2010–2011, was comprised of 274 blood samples of sober drivers (269 men and 5 women). 126 drivers within the group died immediately on the spot (mean age 29.7 years, range 19–53 years), 31 drivers survived the accident (mean age 32.4 years, range 24–69 years), and 117 drivers were stopped for traffic control (mean age 26.4 years, range 17–49 years). ELISA immuno-enzymatic blood tests detecting medicines and psychoactive substances were performed by the Neogen company. The presence of the tested substances was confirmed by gas chromatography and liquid chromatography with a mass detector (GC/MS and LC/MS).
Results. From the total number of 274 individuals, the presence of psychoactive substances was found in 132 cases, which accounted for 48.2% of all subjects. The drivers found to be under the influence of medicines and psychoactive substances were most often stopped for a roadside survey, among whom the percentage of positive results was 92.3% (108 cases out of 117 subjects). Among the total number of positive findings the psychoactive substances used, alone or in combination with other agents, were tetrahydrocannabinols (42.4%), amphetamines (26.5%), opiates (25.7%) and benzodiazepines (15.1%), and their concentration in the blood did not exceed toxic levels.
Conclusions. In the group of psychoactive substances most often used, either alone or in combination with other agents, there were tetrahydrocannabinols, whose high percentage of positive results in drivers stopped for a roadside control may be explained by commissioning studies on early screening. Concentrations of the substances in most cases did not exceed toxic levels. Roadside examinations, on the basis of their alcohol-like effect, were performed primarily on male drivers (**Adv Clin Exp Med 2014, 23, 2, 245–251**).

Key words: drivers, road accidents, psychoactive substances, drugs.

In recent years, the issue of road users in charge of motor vehicles under the influence of medicines and psychoactive substances has been observed [1–4]. The use of medicines to combat stress, depression and insomnia, as well as psychoactive drugs, affects physical and mental health. Medicines and psychoactive substances usually cause cognitive and psychomotor capability decline, impairing perception, causing blurred vision, inhibiting self-criticism and extending the reaction rate [5–7]. Taking these substances is especially dangerous for drivers as it can lead to collisions and accidents [8]. Due to the growing number of intoxicated road users involved in road accidents in the country, as well as the growing number of fatalities resulting from accidents involving intoxicated road users in the Podlasie Province in 2010–2011 [9], an analogous attempt was made to assess the incidence and

levels of concentrations of drugs and psychoactive substances in the blood of traffic fatalities, the accident participants who survived and the drivers stopped by the police for a roadside survey. The assessment was based on the material of the Department of Forensic Medicine, Medical University of Bialystok in the years 2010–2011.

Material and Methods

The study object included 274 blood samples of drivers who died at the scene (mean age 29.7 years, range 19–53 years) and the surviving accident participants who suffered injuries for a period of time exceeding 7 days (mean age 32.4 years, range 24–69 years), as well as people driving motor vehicles stopped for a roadside survey by the police (mean age 26.4 years, range 17–49 years). The analysis conducted in the department in 2010–2011 included 103 blood samples taken during medicolegal autopsies, 23 blood samples taken from the deceased, sent from the site (including the Podlasie Province and neighboring provinces), and 31 blood samples from drivers who survived the accident. Another 117 blood samples were taken from drivers from whom the blood was collected at hospital outpatient clinics in routine roadside surveys. All blood samples were examined at the Department of Forensic Medicine in Bialystok on the basis of specific requests from the Prosecutor's Office and the police, which did not include blood tests for alcohol content. In all cases, previous studies on blood alcohol content came out with negative results, and entities engaged in the criminal investigations directing the blood to be tested by the Department of Forensic Medicine, Medical University of Bialystok, decided to expand the toxicological studies panel. In all cases, the blood was collected with standard glass vial vacuum packages with a valid shelf life period.

The ELISA immuno-enzymatic blood tests detecting medicines and psychoactive substances were performed by the Neogen company. Reagent combinations were used for the detection of amphetamine, amphetamine/MDMA, cocaine and benzoylecgonine, tetrahydrocannabinols and its metabolites, medicines of benzodiazepines and the opioid compound group. In order to confirm the presence of the tested substances, the blood was analyzed by gas chromatography and liquid chromatography with a mass detector (GC/MS and LC/MS). The collected data was statistically analyzed in terms of the adopted distribution criteria and presented in a descriptive form and charts.

Results

In the study group of 274 drivers, examined in 2010–2011, there were 269 men and 5 women. As a result of traffic accidents, within this group, there were 124 men and two women killed. From the remaining 148 drivers, blood was taken either after a road accident during which the participants had not suffered fatal injuries, or at hospital outpatient clinics as part of a routine roadside survey. During the study, the vast majority were car drivers, equaling 269, which accounted for 98.2%. The other people were motorcyclists.

Among the 126 deceased, in 13 cases the presence of psychoactive substances was revealed, which accounted for 10.3% of the samples in this group. In the group of 31 drivers injured in road accidents, the percentage of "positive" results in the test samples was 35.5, corresponding to 11 cases. However, in the cases of the 117 drivers tested in hospital outpatient clinics within a routine roadside survey, the presence of psychoactive substances in the blood was confirmed in 108 patients (92.3%) (Table 1).

Table 1. Distribution of "positive" cases according to the category of drivers

	Drivers who died at the scene	**Drivers who survived accident**	**Drivers stopped for a roadside survey**
The number of examined blood samples	126	31	117
The number of "positive" blood samples	13	11	108
The percentage of "positive" blood samples	10.3%	35.5%	92.3%

In the group of psychoactive substances, which were present in a total of 132 drivers (48.2% of all subjects), tetrahydrocannabinols (THC) accounted for the largest percentage, which taken alone or in combination with other substances, were found in 56 cases (42.4% of all "positive" results). The tetrahydrocannabinols were especially often abused by people stopped for the roadside survey (53 cases – 40.1% of all "positive" results). The presence of amphetamine and opiates in the drivers' blood was reported in a similar number of subjects – 35 people for amphetamine and 34 people for opiates, which accounted for 26.5% and 25.7% of all "positive" results.

In 26 cases, amphetamine was found as the only substance, including over 19 people checked in roadside surveys, with 4 fatalities and 3 people who survived a road accident. Among the 9 people whose blood was found to contain amphetamine along with other substances (tetrahydrocannabinols, opiates and benzodiazepines), they were all drivers stopped by the police for a roadside survey. In the group of 34 people whose blood revealed the presence of opiates, 21 people had only taken morphine. In 7 cases, the presence of morphine was found together with tetrahydrocannabinols, in 5 cases including benzodiazepines, and in 1 case together with amphetamine. These results were found only in blood taken from drivers as a result of a roadside survey.

The benzodiazepine class of medicines was found in the blood of 22 patients (15.1%), 2 of which referred to road accident victims – a deadly one and one who survived the accident. Other "positive" results (20 people) were found in the drivers controlled by the police. In that group of 22 people, solely benzodiazepines were detected in 9 cases. Benzodiazepines together with opiates were detected in 5 individuals. Six people were under the additional influence of tetrahydrocannabinols (3 blood samples) or amphetamine (also 3 blood samples).

The substance most rarely taken by drivers was cocaine. Cocaine and benzoylecgonine were found in 4 cases, and related only to the drivers stopped for a roadside survey. The presence of benzoylecgonine proved cocaine had been used earlier. In 2 cases, benzoylecgonine was detected together with tetrahydrocannabinoids.

In 7 tested samples, the presence of medicines and other substances that could affect the psychomotor performance of drivers was revealed. These were promazine and amitriptyline (in three cases identified among the fatalities), buprenorphine, doxepin and carbamazepine (in one case identified among drivers who survived an accident). One person stopped for a roadside survey drove a vehicle under the influence of toluene (Table 2).

The analysis of the tested substance concentrations was based on the charts of Winek et al., 2001 [10]. In the blood of two traffic fatalities, the indicated concentrations of THC were 2.1 and 5.3 ng/mL, thus ranged within the concentrations considered effective (> 2.5 ng/mL). Within this group of subjects, morphine was determined in the blood of 3 deceased, in 1 case at a therapeutic concentration (< 100 ng/mL). In the blood of the deceased victims, the presence of amitriptyline (2 cases) was also found as well as promazine (1 case) and amphetamine (4 cases), whose concentrations did not

Table 2. The number and prevalence of medicines and psychoactive substances in the blood samples

	Drivers who died at the scene	**Drivers who survived accident**	**Drivers stopped for a roadside survey**	**The number of "positive" blood samples**	**The percentage of "positive" blood samples**
Tetrahydrocannabinols	2	1	36	39	29.5
Tetrahydrocannabinols + Benzodiazepines	0	0	3	3	2.3
Tetrahydrocannabinols + Opiates	0	0	7	7	5.3
Tetrahydrocannabinols + Amphetamine	0	0	5	5	3.8
Tetrahydrocannabinols + Cocaine, Benzoylecgonine	0	0	2	2	1.5
Cocaine and Benzoylecgonine	0	0	2	2	1.5
Amphetamine	4	3	19	26	19.7
Amphetamine + Opiates	0	0	1	1	0.8
Amphetamine + Benzodiazepines	0	0	3	3	2.3
Opiates	3	3	15	21	15.9
Benzodiazepines	1	1	9	11	8.3
Other	3	3	1	7	5.3
Total	13	11	108	132	100

exceed the therapeutic or effective concentration range (respectively: < 250 ng/mL, < 1000 ng/mL < 110 ng/mL). However, a concentration exceeding the therapeutic level was found in one person who had taken estazolam (> 100 ng/mL).

Among the car accident injuries, the presence of THC was reported in the blood of one person (3.1 ng/mL). Morphine was detected in the blood of 2 people, one in therapeutic concentration (< 100 ng/mL) and one exceeding the therapeutic concentration (> 100 ng/mL). For other detected substances, amphetamine (3 cases), carbamazepine, doxepin, buprenorphine, codeine and alprazolam (1 case), the concentration found did not exceed the therapeutic or effective level (respectively: < 110 ng/mL; < 12000 ng/mL, < 250 ng/mL < 110 ng/mL, < 340 ng/mL, < 102 ng/mL).

In the blood of 53 people, all stopped for a roadside survey, THC was detected with a concentration range of 2.1–12.3 ng/mL, including 14 people with concentrations in excess of 2.5 ng/mL. In this group of subjects, amphetamine was indicated in the blood of 28 people, and in 7 cases these concentrations exceeded the level considered to be effective. In 27 drivers, morphine was detected, including 8 patients with concentration higher than the therapeutic level. In the blood of the drivers stopped for a roadside check, the presence of benzodiazepines (diazepam – 14 cases, clonazepam – 4 cases and 1 case of oxazepam and estazolam, were also found) whose concentration did not exceed the therapeutic concentration range (respectively: < 4000 ng/mL, < 75 ng/mL, < 1400 ng/mL, < 100 ng/mL). In the blood of this group of patients, there was also the presence of benzoylecgonine (4 cases), proving cocaine had been used earlier. Moreover, in one case, a therapeutic level of codeine was detected (< 340 ng/mL), and in one case, toluene at a concentration considered to be fatal (> 10000 ng/mL) (Table 3).

Table 3. The level of medicines and psychoactive substances in the blood samples of drivers (single values of concentrations of the substances are presented as data from one person, and in a range of concentrations in several probes)

Kind of substance	**Road accidents**		**Drivers stopped for a roadside survey**
	Drivers who died at the scene	**Drivers who survived the accident**	
	Concentration in blood ng/mL	**Concentration in blood ng/mL**	**Concentration in blood ng/mL**
Tetrahydrocannabinols	2.1–5.3	3.1	2.1–12.3
Benzodiazepines	0	0	0
Diazepam	0	0	85.1–232.0
Oxazepam	0	0	83.1
Clonazepam	0	0	33.8–64.7
Estazolam	125.0	0	39.0
Alprazolam	0	89.4	0
Amphetamine	52.8–103.8	35.0–98.4	37.4–155.2
Opiates	0	0	0
Morphine	47.1–198.3	28.7–141.0	35.7–221.3
Codeine	0	97.3	128.1
Benzoylecgonine	0	0	59.7–117.3
Others			
Promazine	34.5	0	0
Buprenorphine	0	109.7	0
Amitriptyline	110.0–183.5	0	0
Doxepin	0	173.0	0
Carbamazepine	0	2530.0	0
Toluene	0	0	17400.0

Discussion

The issue of driving under the influence of medicines and psychoactive substances among drivers has become the subject of research in recent years, both in Poland and in other countries [1, 5–7, 11, 12]. The studies conducted in 2007 by the NHTSA (National Highway Traffic Safety Administration), in 48 states of the U.S.A. among 10,000 drivers regarding the presence of 75 psychoactive substances and their metabolites (including illegal substances, or substances available without a prescription), showed 11% positive results in the group of daytime drivers and 14.4% of positive results among the nighttime drivers [13]. In the United States, driving under the influence of drugs is associated both with taking drugs, and the use of some medicines, for example in the treatment of chronic pain [12].

In Poland in 2011, the police conducted 5,679,950 sobriety checks and 10,594 controls of the presence of substances with alcohol–like effects (medicines and psychoactive substances). A similar number of 10,000 drivers were tested each year in the last decade in Norway, on suspicion of driving under the influence of alcohol or medicines and psychoactive substances [14]. According to the police statistics, in 2011 there were more than 110,023 drivers stopped in Poland under the influence of alcohol or substances with alcohol–like effects [9].

Due to the fact of the increasing number of drivers under the influence of alcohol and medicines and psychoactive substances in Poland and in 19 other countries of the European Union, the DRUID "Driving Under the Influence of Drugs, Alcohol and Medicines" program was initiated. Its final results were provided to the public in the form of detailed reports during the Program Summary Symposium on 27–28 September, 2011 in Cologne, Germany. The analysis conducted found that there is a wide variation in the prevalence of driving under the influence of psychoactive substances across Europe, from about 2.85% in Finland (including 0.64% under the influence of alcohol) to approximately 14.85% in Spain (including 3.92% under the influence of alcohol). The same study in Poland revealed 2.37% of people driving after the consumption of psychoactive substances, including 1.47% under the influence of alcohol [15]. The research carried out simultaneously in Finland studying the presence of medicines in drivers' blood on the basis of post-mortem examinations, and samples submitted for analysis by the police, revealed that the most common medications taken by drivers were benzodiazepines [16]. Similar results were obtained in other Scandinavian countries [1, 14, 17, 18].

In our examination, as well as within the DRUID program including the territory of Poland, the highest percentage in the group of substances with alcohol-like effects went to tetrahydrocannabinols, which were taken alone or in combination with other substances. The significantly high rate of tetrahydrocannabinol use among drivers was noted by Jones et al., during an analysis in Sweden in 1994–2004, the phenomenon of "driving under the influence of alcohol, medicines and psychoactive substances" [19]. Similarly, a high percentage of positive results for tetrahydrocannabinols in drivers' blood analysis was recorded in 2005 by an Italian team of researchers, assessing the effects of alcohol and the phenomenon of substances acting similarly to alcohol, on the risk of physical injury to drivers who underwent subsequent hospitalization [20]. In the case of medicines, as in Scandinavian countries [21, 22], in the analyzed blood samples of drivers, we most often found the presence of benzodiazepines, which in our studies in more than half of the cases were taken with other substances. However, in a study published last year by Bogstrand et al., conducted in a group of drivers admitted to the Traffic Accidents Trauma Treatment Center in Oslo, it was found that drivers who did not suffer fatal injuries most commonly used amphetamine [23]. Amphetamine was also most frequently consumed in the group of 1403 road fatalities in Sweden in 2003–2007 [21], and a group of persons stopped for traffic control in Sweden in 2001–2004 [24]. In our research, amphetamine was the second-most common psychoactive substance, after tetrahydrocannabinols, which can be explained by the higher purchase price of the drug and its smaller availability than THC. Furthermore, we found that drivers take opiates as often as amphetamine and within this group, in more than half of the cases it was morphine that was taken most often. The same relationship in the study published in 2008 was found by Jones et al. [25].

In all the examinations cited in the discussion, there were no significant concentrations exceeding the toxicity values. Similar results were noted in our study, with the exception of toluene, the single occurrence in the mortal range can be explained by the adaptation to chronic use of solvents containing this compound [10, 26].

In Scandinavian countries, due to the increasing percentage of people taking medicines and substances with alcohol-like effects, legal attempts were made to regulate the limit of concentration thresholds of selected substances, from a "zero tolerance" principle in Sweden, to the determination of the maximum concentration thresholds in the blood of drivers in Denmark [24, 27, 28]. Blood tests are treated as the gold standard in these cases

due to the proven analytical methods and the possibilities of results interpretation relatively well described in the literature [28]. According to the authors' assessment of concentrations of selected substances in the blood, a reasonable action requires individual interpretation of each case.

The authors concluded that in the group of substances with alcohol-like effects taken alone or in combination with other agents, tetrahydrocannabinols were the most common. A much higher percentage of positive results in drivers stopped for a roadside survey compared to drivers with injuries or fatal cases can be explained by commissioning an analysis after earlier screening. The concentration of the tested substances in most cases did not exceed toxic levels, excluding toluene, which was found with a concentration considered to be fatal, indicating the tolerance formation to the compound. Research on the content of substances with alcohol-like effects was done primarily on male drivers.

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