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ORIGINAL ARTICLE

Prevalence of cocaine and derivatives in blood and urine samples of trauma patients and correlation with injury severity: a prospective observational study

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Abstract
Purpose The abuse of cocaine and its derivatives presents a likely risk factor for injury. Trauma incurred by cocaine and derivative abusers may be more severe than that incurred by non-users.
Objectives To ascertain the presence of cocaine and its derivatives in trauma patients and to correlate RTS (Revised Trauma Score) and ISS (Injury Severity Score) with the presence of cocaine and its derivatives in blood and urine samples.
Methods All trauma victims treated in an emergency unit between November 11, 2012 and September 15, 2013 were included in the study. Blood and urine samples were collected on admission to hospital. RTS and ISS scores were then compared with the presence or absence of cocaine and its derivatives in the samples. The associations between RTS < 7.84 and ISS > 16 and the independent variables were evaluated by the gross odds ratio values, determined by univariate logistic regression. Multivariate analysis was performed using multivariate logistic regression.
Results Of 453 patients (83.7% male) included in the study, 28.6% presented ISS > 16 and 33.6% presented RTS < 7.84. A total of 435 samples were collected, and 86 (19.8%) provided positive samples for cocaine, 48 (11%) for crack and 69 (15.9%) for cocaethylene. Compared to other patients, drug users showed a greater probability of RTS < 7.84 (2.18 times greater) and a greater probability of ISS > 16 (1.76 times greater).
Conclusion For the trauma patients included in our study, the use of cocaine and its derivatives was shown to be associated with more severe traumas, as demonstrated by their RTS and ISS scores.

Keywords Trauma · Emergency · Cocaine · Crack · Severity

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Introduction

Psychoactive substances (PS) are those which, when used, have the potential to change consciousness processes, mood and individual thoughts [1]. Currently, the consumption of PS should be considered as a cause of psychosocial and health problems, not only among dependents but also for individuals with intermittent use. A high morbidity, due to the use of psychoactive substances (PS), and the increasing

prevalence of their use and dependence in Brazil, and around the world, make them a good candidate for a study [2].

The abuse of cocaine and its derivatives is related to a significant percentage of emergency room visits [3].

The prevalence of cocaine use in 20

12 included 2% of the adult Brazilian population. Crack consumption increased from 0.7% of the adult Brazilian population in 2006 to 1.4% in 2012 [2]. In the USA, 0.6% of the population, or 1.5 million people, used cocaine in 2014 [4].

Trauma is often a reason for these drug users to seek emergency services, given the already established association between cocaine use and trauma [5, 6]. Hospitalization time is important to enhance the recognition of the harm done due to PS, and it is important for health teams to be prepared [6].

The effects of cocaine on behavior, and the context of PS use, can increase the risk of trauma to the user. In addition, the direct physical effects of PS on the body can adversely affect hospitalization outcomes [7, 8].

The combination of cocaine and alcohol use is quite common and is known to form a substance called "cocaethylene" in the body. Various studies have addressed the cardiac toxicity of cocaethylene, and they show that the simultaneous ingestion of alcohol and cocaine causes a more intense myocardial depression than the isolated use of cocaine [9, 10].

In this study, we used trauma patients to analyze, by way of laboratory analyses, the presence of cocaine and its derivatives in blood and urine at the time of admission to an Emergency Unit (EU). Our objective was to relate trauma severity with positive tests for PS.

Method

Sampling and data collection

A quantitative, cross-sectional and longitudinal study, conducted at the Clinical Hospital of the University of Campinas (Unicamp), in the city of Campinas, Brazil.

The EU surgery department serves an area which includes the city of Campinas as well as other cities in the same region, totaling 20 municipalities. In 2016, the metropolitan region of Campinas had a population of 3.1 million inhabitants.

Inclusion criteria were: age greater than 18 years, admission to the EU due to trauma, first aid treatment carried out by the Division of Trauma Surgery of the University of Campinas, and time spent in the EU or hospital 6 h or greater. Trauma was defined as "any damage caused by a sudden exposure to physical agents, such as mechanical energy, fire, electricity, chemical agents, or radiation, that interacts with the body to a degree that exceeds the limits of human tolerance" [11].

All patients who arrived in the EU as a result of trauma were invited to participate in the study. Informed consent was obtained from all participants in the study. For those patients who arrived unconscious or who died, those responsible for them signed instead.

Data were collected during 44 weeks, from November 11, 2012 to September 15, 2013. The cohort was consecutive. During the data collection period, all patients who entered the EU and met the inclusion criteria were selected to participate in the study. Those responsible for sample collection and patient selection stayed in the ER and the samples were taken at three different times: early in the morning, for patients admitted during the night; at midday, for patients admitted during the morning, and in the early evening, for patients admitted during the afternoon. The nursing and surgery teams both participated in sample collection as well as patient selection.

Toxicological analysis

Toxicological screening was performed on all blood and urine samples, which were collected on admission.

Blood alcohol concentration (BAC) was determined by headspace sampling and gas chromatography with flame ionization detection (HS-GC-FID).

For cocaine and THC screening, urine samples were analyzed by immunoassay, with cutoff values of 150 and 50 ng/mL for cocaine metabolite (benzoylecgonine) and THC metabolite (carboxy THC), respectively. Confirmation of positive results was achieved by gas and liquid chromatography with mass spectrometry (GC-MS and LC-MS). In cocaine confirmatory analyses, it was possible to identify the metabolites anhydroecgonine and anhydroecgonine methyl ester, both crack biomarkers [12]. When urine samples were not available for immunoassay drug screening, drug analyses were performed on blood samples, and were submitted to liquid–liquid extraction prior to GC-MS or LC-MS analysis.

The primary outcomes were the Injury Severity Score (ISS) [13] and Revised Trauma Score (RTS) [14]. For this study, altered RTS values lower than 7.84 and altered ISS values greater than 16 [15] were considered.

All data were analyzed using SPSS V16.0 software (SPSS Inc., Chicago, IL, USA).

The prevalence of RTS-altered and ISS-altered traumas were determined in relation to drug use, type of trauma, age quartiles, gender, education, work activity and marital status. The associations between the primary outcomes (RTS and ISS) and the independent variables were evaluated by the crude Odds Ratio. Multivariate analysis was performed using non-conditional multivariate logistic regression.

This research was approved by the University of Campinas Research Ethics Committee, Document Number 185.108.

Table 1 Injury mechanisms according to mean and standard deviation of RTS and ISS for patients diagnosed with trauma, treated at the EU, HC Unicamp, between November 2012 and September 2013

Injury mechanism	*N* (%)	RTS		ISS	
		Mean	SD	Mean	SD
Blunt					
Motorcycle crash	121 (26.8)	7.0188	1.6299	14.68	13.00
Vehicle crash	76 (16.8)	6.7734	1.7360	16.13	12.90
Hit by vehicle	52 (11.5)	6.4472	1.7979	14.81	11.04
Fall from height	28 (6.2)	7.4815	0.8894	4.53	4.10
Fall from high height	48 (10.6)	7.5276	1.067	8.07	9.26
Assault	38 (8.4)	6.8201	1.7767	11.54	9.59
Other	42 (9.1)	7.7751	0.2842	6.83	8.405
Penetrating					
Stab wound	22 (4.9)	6.7990	1.7596	11.14	8.962
Gunshot wound	26 (5.7)	6.7492	1.6887	16.14	10.91

SD standard deviation

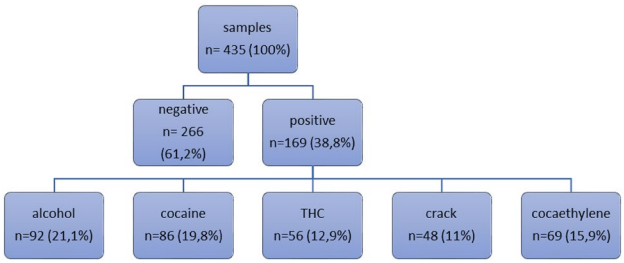

Fig. 1 Laboratory analysis of blood and urine samples taken from trauma patients treated in the EU at HC Unicamp between November 2012 and September 2013

Results

During the data collection period, all patients who entered the EU and met the inclusion criteria were selected to participate in the study. Only those who stayed less than 6 h in the EU and those who did not consent to participate were not included in the study.

During the study period, 485 people meeting the inclusion criteria were admitted to the EU. 32 did not consent to participate, so 453 subjects were included in the study. 435 patients gave blood and urine samples. The mean age was 36.3 years and the median age 31, ranging from 18 to 90 years old. 83.7% of the sample were male.

According to the trauma scores, 28.7% of the subjects ($n=130$) presented ISS > 16 and 33.6% ($n=152$) presented RTS < 7.84.

Table 1 shows injury mechanisms according to RTS and ISS statistics.

Figure 1 shows the results obtained by the laboratory analysis of crack, cocaine and cocaethylene in urine and blood samples. A total of 435 samples were collected, of which 169 (38.8%) were positive for PS, with a predominance of alcohol and cocaine.

The relationships between RTS and selected variables are shown in Table 2.

The variables "Drug use" and "Type of trauma" showed to have significant associations with altered RTS values. After multivariate analysis was performed, only the "Drug use" variable remained under consideration, since the chance of having altered RTS values was 2.18 times greater in the group of patients that used cocaine and crack (=Ethyl) [ORaj = 2.18 (CI 95% 1.32, 3.60)] and 2.73 times greater in the "Other drugs" group [ORaj = 2.73 (CI 95% 1.63, 4.59)]. Table 3 shows the results of the RTS multivariate analysis.

The relationships between ISS and selected variables are shown in Table 4.

Only the variable "Drug Use" showed to have a significant association with ISS > 16. The probability was 1.76 times higher in the group that used cocaine, crack and cocaethylene (adjusted OR = 1.76 (CI 95% 1.08, 2.88), $p=0.023$).

The value of "Stable union" for the variable "Marital status" was shown to be significant, but the value was not known for 111 of the patients, or 24.5% of the sample. For a more accurate analysis, it was excluded from the multivariate logistic regression.

Table 5 shows the results of the ISS multivariate analysis.

Discussion

Our results show that, among the trauma patients included in this study, the use of cocaine and its derivatives is associated with a greater severity of trauma, according to their trauma scores.

This paper addresses two important public health problems: trauma and the harmful use of PS. Both have an impact upon the working age population and can limit their functioning in several areas, affecting social behavior as well as affective and labor relations. This is due to the high rate of serious and often disabling consequences which occur when the two problems coincide.

To provide reliable results in analytical toxicology analyses, samples need to be taken as soon as possible. For example, blood alcohol concentrations decrease over time and remain undetectable after 6 h (using 0.1 g/L as the limit of detection). The inclusion of patients referred by other units, which had already administered first aid, would have resulted in an increased number of negative samples, due to the metabolism of alcohol by the body, causing a false-negative rate.

The use of cocaine by some patients in this study was confirmed by way of laboratory analyses of blood and urine samples collected on EU admission. There was a high

Table 2 Type of drug, type of trauma, age, gender, education, work activity and marital status according to altered RTS scale for patients diagnosed with trauma, treated at the EU, HC Unicamp, between November 2012 and September 2013

	RTS/altered		RTS/not altered		Total	*P*	OR	CI 95%
	N	%	*N*	%				
Type (ud = 19)								
Cocaine + crack + cocaethylene	39	43.8	50	56.2	89	0.002	2.18	1.32–3.60
Other drugs	39	49.4	40	50.6	79	< 0.001	2.73	1.63–4.59
No PS	70	26.3	196	73.7	266		1.00	
Type of trauma (ud = 1)								
Violence	37	43.0	49	57.0	86	0.042	1.65	1.02–2.66
Other	115	31.4	251	68.6	366		1.00	
Age quartiles (ud = 1)								
18–24	44	37.3	74	62.7	118	0.138	1.54	0.87–2.71
25–31	34	30.6	77	69.4	111	0.699	1.14	0.63–2.06
32–45	45	37.8	74	62.2	119	0.117	1.57	0.89–2.77
46–90	29	27.9	75	72.1	104		1.00	
Gender (ud = 1)								
Male	134	35.4	244	64.6	378	0.066	1.71	0.96–3.03
Female	18	24.3	56	75.7	74		1.00	
Schooling years (ud = 110)								
8 or less	34	21.1	127	78.9	161	0.918	0.97	0.51–1.84
9–11	21	21.2	78	78.8	99	0.938	0.97	0.48–1.98
12 or more	18	21.7	65	78.3	83		1.00	
Work activity (ud = 109)								
No	16	26.7	44	73.3	60	0.286	1.42	0.75–2.89
Yes	58	20.4	226	79.6	284		1.00	
Civil status (ud = 108)								
Single	32	22.7	109	77.3	141	0.307	1.39	0.74–2.62
Stable union	14	30.4	32	69.6	46	0.074	2.07	0.93–4.61
Separated	11	26.2	31	73.8	42	0.230	1.68	0.72–3.92
Widow(er)	1	14.3	6	85.7	7	0.831	0.79	0.09–6.94
Married	19	17.4	90	82.6	109		1.00	

P Wald test probability, *OR* odds ratio not adjusted, *CI95%* confidence interval of 95%, *UD* unknown data

Table 3 Type of PS according to odds ratio adjusted for altered RTS for patients diagnosed with trauma, treated at the EU, HC Unicamp, between November 2012 and September 2013

	P	Adjusted OR	CI 95%
Type (ud = 19)			
Cocaine + crack + cocaethylene	0.002	2.18	1.32–3.60
Other drugs	< 0.001	2.73	1.63–4.59
No PS		1.00	

P Wald test probability, *OR* odds ratio not adjusted, *CI 95%* confidence interval of 95%, *UD* unknown data

positive rate for illicit PS, mainly cocaine and crack, showing a higher rate than that found in surveys conducted within the general Brazilian population, based on referred data [2]. In a Brazilian cross-sectional study which assessed patients admitted to the emergency room after a non-fatal injury in 2005, 3.3% of the patients tested positive for cocaine, a rate which is higher than that for the general Brazilian population [16].

It is considered that PS users tend to suffer more trauma than the general population. This can be attributed to the common circumstances which involve trauma events and the use of cocaine and its derivatives [6]. Other studies have also associated cocaine use with a greater risk of trauma [17], attributing it, amongst other events, to stressful living conditions, such as the involvement in violent situations which are associated with the search and purchase of the substance.

In the USA, in 2013, 6% of cocaine users were exposed to some form of violence when attempting to buy the substance [18]. They are also more likely to suffer violent deaths. A study conducted in Oklahoma showed that 9% of the firearm death victims had cocaine metabolites in their blood [19].

A Brazilian study, which followed crack users for 12 years, showed a high mortality rate (20.6%) among this

Table 4 Type of drug, type of trauma, age, gender, education, work activity and marital status according to severity of trauma on the ISS scale for patients diagnosed with trauma, treated at the EU, HC Unicamp, between November 2012 and September 2013

	ISS/SEVERE		ISS/Mild		Total	*P*	OR	CI 95%
	N	%	*N*	%				
Type (ud = 19)								
Cocaine + crack + cocaethylene	41	46.6	47	53.4	88	0.029	1.76	1.08–2.88
Other drugs	32	40.5	47	59.5	79		1.38	0.82–2.31
No PS	87	33.1	176	66.9	263	0.225	1.00	
Type of trauma (ud = 1)								
Violence	37	43.5	48	56.5	85	0.156	1.42	0.88–2.29
Other	128	35.3	235	64.7	363		1.00	
Age quartiles (ud = 1)								
18–24	46	39.3	71	60.7	117	0.221	1.42	0.81–2.48
25–31	40	36.4	70	63.6	110	0.444	1.25	0.71–2.21
32–45	47	39.5	72	60.5	119	0.210	1.43	0.82–2.49
46–90	32	31.4	70	68.6	102		1.00	
Gender (ud = 1)								
Male	145	38.7	230	61.3	375	0.070	1.67	0.96–2.91
Female	20	27.4	53	72.6	73		1.00	
Schooling years (ud = 110)								
8 or less	46	28.8	114	71.3	160	0.753	1.10	0.61-2.00
9–11	27	27.6	71	72.4	98	0.914	1.04	0.54–2.01
12 or more	22	26.8	60	73.2	82		1.00	
Work activity (ud = 109)								
No	13	22.0	46	78.0	59	0.253	0.68	0.35–1.32
Yes	83	29.4	199	70.6	282		1.00	
Civil status (ud = 108)								
Single	39	27.7	102	72.3	141	0.922	1.03	0.59–1.81
Stable union	20	43.5	26	56.5	46	0.048	2.07	1.005–4.26
Separated	10	24.4	31	75.6	41	0.738	0.87	0.38–1.99
Widow(er)	0	0	7	100.0	7	0.999	0	–
Married	29	27.1	78	72.9	107		1.00	

P Wald test probability, *OR* odds ratio not adjusted, *CI 95%* confidence interval of 95%, *UD* unknown data

Table 5 Type of PS according to odds ratio adjusted for severity of trauma according to ISS for patients diagnosed with trauma, treated at the EU, HC Unicamp, between November 2012 and September 2013

	P	Adjusted OR	CI 95%
Type (ud = 19)			
Cocaine + crack + cocaethylene	0.023	1.76	1.08–2.88
Other drugs	0.225	1.38	0.82–2.31
No PS			

P Wald test probability, *OR* odds ratio not adjusted, *CI 95%* confidence interval of 95%, *UD* unknown data

group when compared with the general population at the same age. Of the 131 subjects followed, 16 of them died as homicide victims (12.2%)—a rate much higher than that of the general population of the city of São Paulo, where the study was conducted [20].

In addition to the users' environment, the psychoactive effects of cocaine itself can cause behavioral changes which make the individual more vulnerable to trauma. Both acute intoxication and cocaine abstinence have initially acute symptoms which can become chronic irritation, anxiety, hetero-aggressiveness, paranoia, hallucinations and psychomotor agitation [21]. There is also a heightening in the feeling of omnipotence, which can lead to both risky and hetero-aggressive behavior [22, 23].

These findings confirm what has already been described about crack-user vulnerability, such as criminal involvement, health problems and risky behavior [24].

The greater risk of trauma is not only restricted to violent situations. With regard to traffic trauma patients, it has been observed that, among cocaine users, intoxication may not necessarily cause loss of attention, but it can increase impulsivity, causing them to disregard risks whilst behind

the wheel. This behavior can increase the frequency of traffic collisions [25].

Blood alcohol levels decrease over time and remain undetectable within 6 h, at least by the methods available to us in this study. The inclusion of patients referred by other units, which had already administered first aid, would have resulted in an increased number of negative samples, due to the metabolism of alcohol by the body, causing a false-negative rate.

Our results show that there is an association between positive blood tests for PS and greater severities of trauma, both for patients with altered RTS and those with ISS values higher than 16. However, this association is not unanimous in literature.

A 2010 study on trauma victims, which analyzed the impact of cocaethylene in the blood on clinical outcome severity, showed that a positive blood sample increased the chance of admission to intensive care sixfold [26]. Other studies attribute the same result to the toxicity of cocaine [7, 8, 27].

Another retrospective study from 2009, evaluating 1096 trauma victims, concluded that the injuries of users and non-users of PS were of similar severities, but that those patients whose samples were positive for cocaine were at an increased risk of developing pneumonia during hospitalization [28].

Another reason for an unfavorable clinical outcome for the cocaine-using trauma patient (or indeed use of its derivatives) may be related to changes in acid–base balance caused by cocaine and metabolites [29].

The use of PS, principally alcohol and cocaine, can be a cause of metabolic acidosis, hydro-electrolyte imbalance and elevated lactate levels. These conditions may also be present in hemorrhagic trauma, which would increase the chances of progression to multiple organ failure [29].

One of the trauma scores adopted by this study was RTS [14]. This score was based on the patient's EU admission data, of which the Glasgow Coma Scale (GCS) carries the greatest weight, and this could have been altered as a result of intoxication by psychoactive substances, and not trauma. Of 15,000 patients in a 2005 multicenter study, 3500 of them tested positive for alcohol and 992 positive for PS. Compared to other patients in the study, whose analyses were negative, the PS users presented lower GCS scores and greater severities of trauma on admission [30].

To avoid this evaluation bias, our study adopted not only RTS but also ISS, whose values are not related to the level of consciousness, but instead to the severity and location of the injuries resulting from the trauma. Our results show that the percentages of subjects with altered RTS, and those with ISS less than 16, were similar. Among the subjects who presented positive samples of PS, the chances of a more severe trauma were higher based on the two scales (1.76 for ISS and 2.18 for RTS).

On the analysis of patients intoxicated by cocaine, a 2009 study found no difference in the GCS values between patients with positive results and those with negative results [28]. Similar results were shown by another, experimental, study, which evaluated cerebral perfusion in animals intoxicated by the substance [31].

One limitation of this study was the inclusion criterion of age being greater than 18 years, which consequently excluded a significant proportion of the population: adolescents of 14–17 years, who also often present problematic use of PS. Another limitation to be considered is the health unit in which the study was carried out. It is a tertiary, university hospital, which demands caution when extrapolating data to other contexts. All personnel involved in traumatic events were not included in this study, only those who were treated at the hospital for trauma. If others involved, particularly those who did not suffer any trauma (for example, aggressors or drivers) had also been included in the study, the percentage of positive samples would probably have been much higher.

Conclusions

There was a greater severity of trauma in those patients who used cocaine and crack associated with alcohol, when compared with non-users of PS. Our findings reinforce the need to establish prevention and intervention measures. Admission to the EU with traumatic injury represents a "teachable moment" for conducting intervention about drug use. Given the prevalence of PS problems in trauma centers, screening, intervention, and counseling for drug-related problems should be routine to reduce this potentially lethal association.

Compliance with ethical standards

Conflict of interest This research was funded by the Brazilian Ministry of Health (00.530.493/0001-71). The authors Karina Diniz Oliveira, Gustavo Pereira Fraga, Emilio Carlos Elias Baracat, André Moreno Morcillo, Rafael Lanaro, José Luiz Costa, Eduardo de Mello Capitani, Fabio Bucaretchi, Augusto Iglesias Ferreira Filho, Vitoria Carneiro Gimenes, Renata Cruz Soares de Azevedo declare that they have no conflicts of interest.

Ethical standards The study was approved by the Unicamp Research Ethics Committee, document number 185.108, which waived the need for informed consent for this observational and anonymous investigation. This manuscript has been created in compliance with internationally accepted ethical standards.

References

1. UNODC, World Drug Report 2013. United Nations publication, Sales No. E.13.XI.6.
2. Laranjeira R, Pinsky I, Caetano R, Mitsuhiro SS, Madruga CS. II Brazilian National Alcohol and Drugs Survey. UNIAD: Unidade de Pesquisas em Álcool e Drogas. São Paulo: UNIFESP: Universidade Federal de São Paulo; 2012.
3. Siegal HA, Falck RS, Wang J, Carlson RG, Massimino KP. Emergency department utilization by crack-cocaine smokers in Dayton, Ohio. Am J Drug Alcohol Abuse. 2006;32(1):55–68.
4. Center for Behavioral Health Statistics and Quality (CBHSQ). Behavioral health trends in the United States: results from the 2014 National survey on drug use and health. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2015. HHS https://www.drugabuse.gov/publications/research-reports/cocaine/what-scope-cocaine-use-in-united-states. Accessed 21 Jan 2017.
5. Figl M, Pelinka LE, Weninger P, Walchetseder C, Mauritz W, Hertz H, Kroepfl A, Schmidhammer R, Buchinger W, Redl H. Urine toxicology screening in Austrian trauma patients: a prospective study. Arch Orthop Trauma Surg. 2010;130(7):883–7.
6. Cordovilla-Guardia S, Guerrero-López F, Maldonado A, Vilar-López R, Salmerón JM, Romero I, Pose S, Fernández-Modéjar E. Trauma risk perception related to alcohol, cannabis, and cocaine intake. Eur J Trauma Emerg Surg. 2014;40(6):693–9.
7. Nanavati A, Herlitz LC. Tubulointerstitial injury and drugs of abuse. Adv Chronic Kidney Dis. 2017;24(2):80–5.
8. Singh V, Rodriguez AP, Thakkar B, Savani GT, Patel NJ, Badheka AO, Cohen MG, Alfonso CE, Mitrani RD, Viles-Gonzalez J, Goldberger JJ. Hospital admissions for chest pain associated with cocaine use in the United States. Am J Med. 2017;130(6):688–698.
9. Herbst ED, Harris DS, Everhart ET, Mendelson J, Jacob P, Jones RT. Cocaethylene formation following ethanol and cocaine administration by different routes. Exp Clin Psychopharmacol. 2011;19(2):95–104.
10. Fettiplace MR, Pichurko A, Ripper R, Lin B, Kowal K, Lis K, Schwartz D, Feinstein DL, Rubinstein I, Weinberg G. Cardiac depression induced by cocaine or cocaethylene is alleviated by lipid emulsion more effectively than by sulfobutylether-β-cyclodextrin. Acad Emerg Med. 2015;22(5):508 – 17.
11. Langley J, Brenner R. What is an injury? Inj Prev. 2004;10(2):69–71.
12. Fiorentin TR, D'Avila FB, Comiran E, Zamboni A, Scherer JN, Pechansky F, Borges PEM, Fröehlich PE, Limberger RP. Simultaneous determination of cocaine/crack and its metabolites in oral fluid, urine and plasma by liquid chromatography-mass spectrometry and its application in drug users. J Pharmacol Toxicol Methods. 2017;86:60–66.
13. Baker SP, O'neill B, Haddon JRW, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care J Trauma. 1974;14(3):187–96.
14. Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the trauma score. J Trauma. 1989;29(5):623–9.
15. Copes WS, Champion HR, Sacco WJ, Lawnick MM, Bain LW. The Injury Severity Score revisited. J Trauma 1988;29:69–77.
16. Reis AD, Figlie NB, Laranjeira R. Prevalence of substance use among trauma patients treated in a Brazilian emergency room. Rev Bras Psiquiatr. 2006;28(3):191–5.
17. Coghlan M, Macdonald S. The role of substance use and psychosocial characteristics in explaining unintentional injuries. Accid Anal Prev. 2010;42(2):476–9.
18. Winstock, A. Highlights and global comparisons 2014. Emergency treatment and exposure to violence. Global Drug Survey; 2014. https://www.globaldrugsurvey.com/past-findings/the-global-drug-survey-2014-findings/. Accessed 21 Jan 2017.
19. Jorgenson KM, Wiens AL, Pfeifer EA, Lanter J. Trends in officer-involved firearm deaths in Oklahoma from 2000 to 2015. J Forensic Sci. 2017. https://doi.org/10.1111/1556-4029.13499.
20. Dias AC, Araújo MR, Dunn J, Sesso RC, de Castro V, Laranjeira RA. Mortality rate among crack/cocaine-dependent patients: a 12-year prospective cohort study conducted in Brazil. J Subst Abuse Treat. 2011;41(3):273–8.
21. Moeller SJ1, Maloney T, Parvaz MA, Alia-Klein N, Woicik PA, Telang F, Wang GJ, Volkow ND, Goldstein RZ. Impaired insight in cocaine addiction: laboratory evidence and effects on cocaine-seeking behaviour. Brain. 2010;133(Pt 5):1484–93.
22. Spronk DB, De Bruijn ER, van Wel JH, Ramaekers JG, Verkes RJ. Acute effects of cocaine and cannabis on response inhibition in humans: an ERP investigation. Addict Biol. 2016;21(6):1186–98.
23. Kalivas PW, Volkow ND. The neural basis of addiction: a pathology of motivation and choice. Am J Psychiatry. 2005;162:(8):1403–13.
24. Ribeiro M, Dunn J, Sesso R, Dias AC, Laranjeira R. Causes of death among crack cocaine users. Rev Bras Psiquiatr. 2006;28(3):196–202.
25. Macdonald S, Mann RE, Chipman M, Anglin-Bodrug K. Collisions and traffic violations of alcohol, cannabis and cocaine abuse clients before and after treatment. Accid Anal Prev. 2004;36(5):795–800.
26. Wiener SE, Sutijono D, Moon CH, Subramanian RA, Calaycay J, Rushbrook JI, Zehtabchi S. Patients with detectable cocaethylene are more likely to require intensive care unit admission after trauma. Am J Emerg Med. 2010;28(9):1051–5.
27. Pavarin R, Lugoboni F, Mathewson S, Ferrari AM, Guizzardi G, Quaglio G. Cocaine-related medical and trauma problems: a consecutive series of 743 patients from a multicentre study in Italy. Eur J Emerg Med. 2011;18(4):208–14.
28. Hadjizacharia P, Green DJ, Plurad D, Chan LS, Law J, Inaba K, Demetriades D. Cocaine use in trauma: effect on injuries and outcomes. J Trauma. 2009;66(2):491–4.
29. Alshayeb H, Showkat A, Wall BM. Lactic acidosis in restrained cocaine intoxicated patients. Tenn Med. 2010;103(10):37–9.
30. Dunne JR, Tracy JK, Scalea TM, Napolitano LM. Lactate and base deficit in trauma: does alcohol or drug use impair their predictive accuracy? J Trauma. 2005;58(5):959–66.
31. McBeth BD, Stern SA, Wang X, Mertz M, Zink BJ. Effects of cocaine in an experimental model of traumatic brain injury. Acad Emerg Med. 2005;12(6):483–90.