


Alcohol and cocaine use prior to suspected suicide: Insights from toxicology

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Abstract

Introduction. This study investigates whether there is a relationship between alcohol and cocaine use in deaths where suicide by self-injury is the suspected cause of death. **Methods.** Adults referred by coroners to the Imperial College London Toxicology Unit for toxicological analysis between 2012 and 2016 were reviewed for inclusion criteria. Those who died by self-injury reasoned to be deliberate were included in the analysis. Femoral blood alcohol concentration (BAC) and presence of cocaine or benzoylecgonine (a metabolite of cocaine) in blood and/or urine were tabulated and odds ratios calculated. **Results.** A total of 1722 decedents met inclusion criteria. BAC was ≥ 50 mg/dL in 29% of decedents. Cocaine was detected in 8.4% of cases. The likelihood of testing positive for cocaine increased with BAC and was most frequent between 100 and 199 mg/dL, consistent with moderate to severe intoxication (odds ratio 5.88, 95% confidence interval 3.80, 9.09; $P \leq 0.001$) compared to those with BAC < 10 mg/dL. **Discussion and Conclusions.** This study demonstrates a correlation between increasing BAC and likelihood of cocaine use prior to suspected suicide, up to a level consistent with severe intoxication. Cocaine use was found in a high proportion of cases relative to the general population reporting regular use. This pattern of drug and alcohol use has previously been given little attention in suicide prevention strategies and clinical prioritisation. [Bailey J, Kalk NJ, Andrews R, Yates S, Nahar L, Kelleher M, Paterson S. Alcohol and cocaine use prior to suspected suicide: Insights from toxicology. *Drug Alcohol Rev* 2021;40:1195–1201]

Key words: alcohol, suicide, cocaine, toxicology.

Introduction

Alcohol and illicit drug use are major modifiable risk factors for suicide, the leading cause of death for men under the age of 49 and women under the age of 34 in the United Kingdom [1]. Both alcohol intoxication and alcohol dependence are associated with an elevated risk of suicide [2–4]. Among the risk factors for suicide in the 2010 Global Burden of Disease Study, alcohol use disorder was second only to depression as the largest contributor to suicide due to mental health disorders [2]. Alcohol is not the only intoxicant that increases suicide risk. There is clear evidence that use and dependence on cocaine are significant risk factors for suicide [2,5]. We know use of cocaine is common

in heavy drinkers [6], but most people with concurrent alcohol and cocaine misuse are not in contact with treatment services [7].

Post-mortem toxicology can give us valuable insights into drug and alcohol use during suicide, which are impossible to obtain by self-reporting if the death occurs quickly or without presentation. Toxicology becomes vital to understand substance use events prior to methods, such as hanging, which is common, highly lethal and difficult to study in living populations [8]. Data currently available in the UK on substance use in suicide are limited to patients in contact with secondary psychiatric services, which accounts for only 28% of suicide decedents [9]. This leaves a majority who never approach services, or are excluded due to

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substance misuse [10], and suggests a gap in our understanding of substance misuse in suicide. We have therefore conducted an exploratory descriptive study in a large toxicological database of alcohol and cocaine use in those decedents who were suspected to have died by suicide due to self-injury. Specifically, we aim to understand if there is a relationship between alcohol and cocaine use during suicides by self-injury.

Methods

Study population

In England and Wales, all violent or unnatural deaths (including suicides) are referred to the coroner. As part of the pathologist's investigation into the cause of death, toxicological analysis may be requested. The Toxicology Unit, Imperial College London, performs toxicological analysis on post-mortem samples submitted by pathologists on behalf of coroners. The coroners' jurisdictions covered by the Unit include seven of the eight jurisdictions in London and some areas from the South East of England (Suffolk, Berkshire, Peterborough and Cambridgeshire), covering approximately 15% of England's population.

All cases in the Toxicology Unit's database between 2012 and 2016 were retrospectively assessed for inclusion criteria. We considered all decedents who died from hanging, carbon monoxide poisoning, asphyxiation, jumping in front of a train, laceration, gunshot wound and immolation, when the act appeared deliberate and self-inflicted. As standard the Toxicology Unit will receive a Request Form, detailing basic demographics of the deceased and the analysis required for the case. Included with the Request Form will be the Coroner's Officer's Report, which details the circumstances of death and often more background information on the deceased. The detail can range from a couple of sentences to several pages and can include prescribed medication. Sometimes post-mortem reports are included with the request form. The circumstances of death are recorded in the Unit's database and in cases, such as hanging, this was recorded as self-inflicted injury. In cases where more than one method was used or intent was not clear from the database, such as 'train death' without additional qualifiers, the paper case file containing the circumstances of death was consulted and where further evidence of intent is found, such as eyewitness reports or suicide notes found with the body, these were treated as self-inflicted. We did not have direct access to the coroner's verdict so referred to the cause of death as 'suspected suicide'. To differentiate these methods from self-poisoning, we will be using the phrase 'suicide by self-injury' to describe these methods. Decedents who died from a suspected overdose of medication

or illicit drugs, jumping from a height, drowning and road traffic collisions were not examined because intent could not be determined from the information available to the Toxicology Unit. Cases with insufficient evidence to conclude suicidal intent, for example unwitnessed train-related deaths, were excluded from analysis.

Toxicological analysis

The *Human Tissue Act* 2004 stipulates that coroners may only conduct analysis relevant to the cause of death. The analyses carried out were therefore determined per case on an individual basis. The analyses specifically requested by the coroner/pathologist (via the sample request form) for each case were taken into account and the age of the victim and the types of samples submitted were also considered. Analysis for alcohol and a general screen of blood for drugs, which includes cocaine, is conducted on almost all cases as standard—provided an appropriate sample is received.

The types of samples used for analysis included post-mortem femoral vein blood, ante-mortem blood or serum (only available if the decedent died in hospital following the suspected suicidal act) and post-mortem urine. Post-mortem blood samples from other sites (e.g. cardiac blood or cavity blood) were excluded from this study.

Measurement of blood alcohol concentration (BAC) was conducted by headspace gas chromatography [11]. The limit of detection of the analytical assay was 10 mg/dL. A BAC of greater than 50 mg/dL was considered positive, as below this the stage of alcohol influence is regarded as subclinical (i.e. no apparent influence on the decedent) [12]. This is the drink-drive limit in most European countries [13].

The presence of cocaine in the blood was determined from the general screen of blood for drugs by gas chromatography–mass spectrometry, which included unknowns, licit and illicit drugs [14]. The blood was considered positive for cocaine if it was detected above the limit of detection of the assay of 0.05 µg/mL.

The presence of cocaine and benzoylecgonine in the urine was determined from the screen of urine for illicit drugs [15]. The urine was considered positive if either of the compounds were identified according to recognised analytical standards (matched to a reference standard by retention time and full scan mass spectrum with a signal to noise greater than 10:1). All analyses were conducted in accordance with the UK and Ireland Association of Forensic Toxicologists' guidelines [16].

Ethical approval

Samples were collected by pathologists and submitted for toxicological analysis at the request of the coroners.

Ethics approval for the use of the data generated from this analysis was granted by the South West London Research Ethics Committee (REC ref: 11/LO/0033). Coroners were informed of the use of the data.

Statistical analysis

Logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI) for the presence of a BAC greater than 50 mg/dL depending on sex, age and co-intoxicant use. Age bins were generated and handled as categorical data. To determine whether cocaine use was more likely at higher BAC, BAC groups were defined [undetectable, 10–50, 50–100 (mild intoxication), 100–200 (moderate to severe intoxication) and > 200 (severe intoxication to comatose) mg/dL] according to toxicological convention [12]. Logistic regression was calculated for cocaine toxicology at each BAC bin. Statistical analysis was carried out on IBM SPSS Statistics version 25.0.

Results

Of the 10 287 cases analysed by the Imperial College Toxicology Unit between 2012 and 2016, 17.1% were due to suspected suicidal acts by self-injury (Table 1). Ten decedents were excluded due to unknown sex and 36 were excluded due to unknown age, yielding a final sample of 1722. 81.2% of decedents were male with a median age of 43 years (interquartile range 22.75),

and 18.2% were female with a median age of 41 years (interquartile range 22.25).

At the time of toxicological analysis, 31% of male and 22.5% of female decedents had a BAC greater than 50 mg/dL (OR 0.65; $P \leq 0.01$) (Table 2). Decedents aged 35 to 44 years were most likely (35.8%) to have a BAC ≥ 50 mg/dL and were significantly more likely than those aged 55 to 64 (OR 0.60; $P \leq 0.01$), 65 to 74 (OR 0.40; $P \leq 0.001$) and 75+ (OR 0.10; $P \leq 0.001$).

Samples were positive for cocaine or cocaine metabolites in 8.4% of decedents. Decedents testing positive for cocaine were significantly more likely to have a BAC ≥ 50 mg/dL at the time of analysis (OR 3.82; $P \leq 0.001$). Of those decedents who had a BAC ≤ 10 mg/dL, 4.2% tested positive for cocaine. In comparison, 9.9% of those with a BAC between 10 and 49 mg/dL tested positive for cocaine (OR 2.50; $P \leq 0.01$), 15.5% of those with a BAC between 50 and 99 mg/dL (OR 4.16; $P \leq 0.001$), 20.6% of those with a BAC between 100 and 199 mg/dL (OR 5.88; $P \leq 0.001$) and 11% of those with a BAC ≥ 200 mg/dL (OR 2.81; $P \leq 0.001$) (Table 3).

Hanging was the most common method of suicide in our sample, with 75.3% of males and 77.8% of females dying by this method. The median age in this group was 42 years (interquartile range 23). Femoral BAC was ≥ 50 mg/dL in 32.3% of decedents. Cocaine or cocaine metabolites were found to be positive in 9.5% of those who died by hanging. Decedents who died by hanging were around twice as likely to have a BAC ≥ 50 mg/dL than the next three most common methods; train deaths (OR 0.53; $P \leq 0.01$), asphyxiation (OR 0.48; $P \leq 0.01$) and laceration (OR 0.43;

Table 1. Demographic characteristics, BAC and method of suicide

Method	Male, <i>n</i> (%) ^a	Female, <i>n</i> (%) ^a	Age, years (IQR)
Hanging	1053 (75.3)	252 (77.8)	42 (23)
Hit by train	123 (8.8)	25 (7.7)	40 (24.25)
Asphyxiation	89 (6.4)	35 (10.8)	40.5 (23.5)
Laceration	67 (4.8)	3 (0.9)	49 (25.25)
Carbon monoxide	33 (2.4)	7 (2.2)	46 (16.75)
Gunshot wound	20 (1.4)	0	68.5 (22.5)
Immolation	13 (0.9)	2 (0.6)	41 (22.5)
Total	1398	324	42 (23)
BAC (mg/dL)	Male, <i>n</i> (%) ^a	Female, <i>n</i> (%) ^a	Total, <i>n</i> (%) ^a
<10	838 (59.9)	226 (69.8)	1064 (61.8)
10–49	126 (9.0)	25 (7.7)	151 (8.8)
50–99	117 (8.4)	12 (3.7)	129 (7.5)
100–199	192 (13.7)	41 (12.7)	233 (13.5)
200+	125 (8.9)	20 (6.2)	145 (8.4)

^aColumn percentages. BAC, blood alcohol concentration; IQR, interquartile range.

Table 2. Association between levels of blood alcohol and demographics, method and cocaine use

Variable	BAC <50 mg/dL, n (% ^a)	BAC ≥50 mg/dL, n (% ^a)	OR (95% CI) ^b
<i>Sex</i>			
Male	964 (69.0)	434 (31.0)	1.00
Female	251 (77.5)	73 (22.5)	0.65 (0.49, 0.86)*
<i>Age, years</i>			
18–24	122 (69.7)	53 (30.3)	0.78 (0.53, 1.15)
25–34	258 (69.0)	116 (31.0)	0.81 (0.60, 1.09)
35–44	246 (64.2)	137 (35.8)	Ref.
45–54	252 (67.2)	123 (32.8)	0.88 (0.65, 1.18)
55–64	159 (75.0)	53 (25.0)	0.60 (0.41, 0.87)*
65–74	90 (81.8)	20 (18.2)	0.40 (0.24, 0.68)**
75+	88 (94.6)	5 (5.4)	0.10 (0.04, 0.26)**
<i>Method</i>			
Hanging	883 (67.7)	422 (32.3)	Ref.
Train	118 (79.7)	30 (20.3)	0.53 (0.35, 0.81)*
Asphyxiation	101 (81.5)	23 (18.5)	0.48 (0.30, 0.76)*
Laceration	58 (82.9)	12 (17.1)	0.43 (0.23, 0.82)*
Carbon monoxide	23 (72.5)	11 (27.5)	0.80 (0.39, 1.60)
Gunshot	13 (65.0)	7 (35.0)	1.13 (0.45, 2.85)
Immolation	13 (86.7)	2 (13.3)	0.32 (0.07, 1.43)
<i>Cocaine present</i>			
Yes	60 (41.7)	84 (58.3)	3.82 (2.70, 5.42)**
No	1155 (73.2)	423 (26.8)	1.00

^aRow percentages. ^b*P*-values * ≤0.01; **≤0.001. BAC, blood alcohol concentration; CI, confidence interval; OR, odds ratio.

Table 3. Odds of testing positive for cocaine at different BAC compared to less than 10 mg/dL

BAC (mg/dL)	Cocaine negative, n (% ^a)	Cocaine positive, n (% ^a)	OR ^b
<10	1019 (95.8)	45 (4.2)	1.00
10–49	136 (90.1)	15 (9.9)	2.50 (1.36, 4.60)*
50–99	109 (84.5)	20 (15.5)	4.16 (2.37, 7.29)**
100–199	185 (79.4)	48 (20.6)	5.88 (3.8, 9.09)**
200+	129 (89.0)	16 (11.0)	2.81 (1.54, 5.11)**

^aRow percentages. ^b*P*-values ** ≤0.01; *** ≤0.001. BAC, blood alcohol concentration; OR, odds ratio.

$P \leq 0.01$). There was no other statistically significant difference in alcohol use between hanging and any other method of self-injury. The highest rate of alcohol use was found in those who died by gunshot deaths (35%), an all-male group, with a median age of 68.5 years.

Discussion

Statement of principal findings

This study involved a large cohort of decedents and through toxicological analysis has given a unique

insight into cocaine and alcohol use prior to suicide—which would be impossible to achieve by other means. We have found a BAC ≥50 mg/dL present in 29% and cocaine present in 8.4% of all cases. Of those who had consumed alcohol, most had a BAC consistent with moderate to severe intoxication [12]. Moderate to severe alcohol intoxication being found so frequently is a worrying finding, with intoxication impairing judgement, and use increasing likelihood of self-harm and suicide attempts [2]. It should also be considered that the presence of such high BACs may reflect alcohol tolerance in this population.

Hanging was the most common method in our sample, reflecting national suicide statistics [17], though it

should be noted that the exclusion of self-poisonings from this study means the proportion of suicide methods reported here will be inflated compared with other studies, including all methods. Those who died by hanging were twice as likely to have a BAC ≥ 50 mg/dL than the next three most common methods of suicide. A higher rate of alcohol use (35%) was only found in gunshot deaths, the only all male group, with a median age higher than any other method (68.5 years). This is likely due to the distribution of firearm ownership in the UK [18].

Cocaine use was found in 8.4% of all suicides by self-injury and in those using alcohol this rose to 16.6%. The Office for National Statistics reports that 2.3% of adults aged 16 to 65 years have used cocaine in the last year and only 0.3% of 16- to 65-year-olds are frequent users of cocaine [19]. Cocaine use is surprisingly prevalent in suspected suicide by self-injury considering the general population's reported use. This study shows that BAC is positively correlated with cocaine use up to severe levels of intoxication. At this level, decedents were nearly six times more likely to have used cocaine than those not using alcohol. Given international data suggests that alcohol and cocaine use disorder are independent predictors of suicide [2], it is concerning that alcohol and cocaine use are correlated in this way.

Comparison with other studies

The National Confidential Inquiry into Suicide and Homicide by People with Mental Illness (NCISH) reports that 45% of people with mental illness who died by suicide in England had a history of alcohol misuse, and 33% had a history of drug misuse [9]. Though finding a higher rate of alcohol use than the presented here, the NCISH looked specifically at those in contact with secondary mental health services. Another key difference is the NCISH did not differentiate between current and historic drug and alcohol misuse. Our findings differ from those of the NCISH in that it presents general population data and reports acute use rather than a history of substance misuse, as well as excluding self-poisonings.

The Multi-centre Study of Self-harm in England reported alcohol use in 54.6% of people presenting to services for the first time with self-harm by self-injury [20]. Our findings show 38.2% of people are using alcohol (BAC >10) during suicide by self-injury—which is lower. The Multi-centre Study of Self-harm in England recorded self-reported alcohol consumption within 6 h of presentation in those presenting with non-fatal self-harm, and alcohol use was associated with future repetition of self-harm. If this difference is

significant, this suggests either the pattern of alcohol use in those presenting with non-fatal self-injury and fatal self-injury is different, that there is a discrepancy between reported and actual use, or in a proportion of people the alcohol being used is no longer at detectable levels at the time the blood samples are taken.

There are well powered post-mortem toxicology studies of suicide deaths in the USA, which show a similar proportion of decedents with significant BACs, though most suicides are by firearm [21]. Direct comparison is complicated by opinion varying on what is considered a significant BAC. Most studies suggest thresholds between 20 and 80 mg/dL [22,23]. A meta-analysis of case controlled and case-crossover studies by Borges *et al.* reported increased risk of a suicide attempt with acute alcohol use. Odds increased with acute alcohol use with 2.71 (95% CI 1.56, 4.71) for 'low levels' and 37.18 (95% CI 17.38, 79.53) for 'high levels'. These risks were considered above and beyond the risk conveyed by chronic alcohol use, suggesting that the higher doses of alcohol use produced a stronger effect on mood [24]. Two of the studies in the meta-analysis demonstrated this risk remained when controlling for use of other drugs [25,26]. Our results show that these 'high level' drinkers are also more likely to be using cocaine.

Another meta-analysis by Cherpitel *et al.* of 37 studies reporting BAC in those who had died by suicide found the number of decedents who tested positive for alcohol varied from 10–69%, median 36% [27]. This median is higher than reported here; however, studies involving BAC vary in their definition of a significant level of alcohol with some reporting any alcohol detected as positive and some a BAC of greater than a threshold value, usually a BAC over the legal limit for driving a motor vehicle. Another key difference is that this is the median for all methods of suicide, where the results presented here exclude self-poisoning. As the eight studies looking specifically at self-poisoning reported a positive BAC in between 7% and 51% of decedents, it is not clear if excluding self-poisonings would lead to over or under-reporting of alcohol use.

Deaths by hanging and gunshot deaths were found to have the highest prevalence of alcohol use in decedents in this study. This is consistent with studies reporting alcohol use and method of suicide, with those using alcohol more likely to choose highly lethal methods [28,29] and also having a more lethal outcome from their most lethal suicide attempt [30].

Choi *et al.* studied decedents in the National Violent Death Reporting System in the USA for alcohol and drug toxicology use in those who died by suicide aged 50 or over. Of those who had a valid test for alcohol (51.9%), around one-third had a BAC >0 [4]. Choi *et al.* did demonstrate an association between testing positive for cocaine and finding a BAC >0 (OR 1.67), but

there was no association between having a BAC greater than their threshold value of 80 mg/dL and testing positive for cocaine. Cocaine was only tested for in 39% of those who died by suicide in the National Violent Death Reporting System and was positive in 2.85% of these. A slightly higher prevalence of cocaine was reported by Sheehan *et al.* in the Colorado Violent Death Reporting System. Of the 69.6% of decedents who died by suicide and were tested for cocaine, 4.4% tested positive [31]. In an earlier study by Darke *et al.*, in New South Wales, alcohol was detected in 40.6% of decedents who died by non-overdose suicide. Cocaine was detected in 1.8% of cases, and in no female decedents [32]. Toxicology was available in 98.5% of cases. The prevalence of cocaine use in suicide in all these studies is lower than presented here (8.4%), with broadly similar reported use of cocaine within the last year in the UK, Australia and Colorado (2.3%, 2.5% and 2.87% respectively in 2016/2017) [33–35].

Strengths and limitations of the study

The size of the study has allowed a robust analysis of both alcohol use and co-intoxication with cocaine in suspected suicide by self-injury. We have been able to analyse patterns of substance use in methods, such as hanging, which are difficult to study in living populations due to their high lethality [36]. Interpretation is limited as in most cases the samples provided only a single BAC measurement, so it is not possible to establish whether alcohol was consumed over a period of hours or immediately prior to the act. Interviews suggest that only a small proportion of people use alcohol to deliberately increase motivation to attempt suicide or to ‘numb fears’ of suicide prior to the attempt [37]. In addition, this study focuses on suicide by self-injury. Not including self-poisonings means the proportions of suicide methods, BACs and cocaine use are not generalisable to all suicides and are harder to directly compare to other studies.

There are of course limitations to all tests. Here we have used BAC as a marker of intoxication, which is a clinical diagnosis and is influenced by the user’s tolerance. Detection of cocaine is constrained by its breakdown in the blood after death by pseudocholinesterases, which makes under-detection a possibility. Testing of body fluids post-mortem is also not suitable for assessing chronic use, which is also a risk factor for suicide—this is more readily detected in hair samples [38]. In some cases, positive toxicology for cocaine was limited to detection of the metabolite in the urine rather than parent compound. This could reflect less immediate use as cocaine metabolites can be detected in the urine for several days in

chronic users [39]. Finally, this study is observational and as such causation cannot be proven, although this is supported elsewhere in the literature [2,3].

Implications for clinicians, policy makers and future research

Here we have demonstrated that alcohol use is a part of many suicides by self-injury and that cocaine use is more common among suicide decedents in comparison to the level of use reported in the general population. Increasing levels of alcohol increased likelihood of testing positive for cocaine in a dose-dependent fashion up to levels consistent with severe intoxication. Further studies in clinical populations, including those using within-subject controls, are needed to tease out the role of alcohol intoxication and alcohol use disorder in suicide in the United Kingdom. In addition, more work needs to be done to inform exactly how people are using cocaine prior to their suicide and to characterise patterns of alcohol and cocaine use in suicidal acts.

Conclusion

The work of this study highlights the need to reconsider the lack of emphasis given to substance use in many national suicide prevention strategies [40] as well as the need for increased public education about, and public health interventions to address alcohol and cocaine use in suicidal acts. For example, Talk to Frank, the public health advice website about substances, does not mention that alcohol or cocaine use is associated with suicide [41]. One example gaining support would be the introduction of minimum unit pricing as discussed in a recent Public Health England evidence review [42]. Clinically, we hope it will energise engagement with depressed or suicidal patients about their alcohol use, and in those who are drinking alcohol lead to enquiries about both infrequent and habitual cocaine use.

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Conflict of Interest

The authors have no conflicts of interest.

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