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Toxicology findings in cases of hanging in the City and County of San Francisco over the 3-year period from 2011 to 2013

A.C. San Nicolas, N.P. Lemos *

Forensic Laboratory Division, Office of the Chief Medical Examiner, Hall of Justice – North Terrace, 850 Bryant Street, San Francisco, CA 94103, United States

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ABSTRACT

In postmortem cases where the cause of death is hanging, toxicological analyses may be considered unnecessary by some medical examiners, toxicologists, and other persons involved in medico-legal investigations because the cause of death seems "obvious." To ascertain if toxicological analyses are necessary when the cause of death is hanging, all 102 hanging cases (25 females; 77 males) from 2011 to 2013 that came under the jurisdiction of the San Francisco Office of the Chief Medical Examiner were examined from a total of 3912 sudden, unexpected, or violent death cases in the same period. Suicide was the manner of death in 99 of these cases, with two accidental and one undetermined death. The average age of decedents was 43.9 years (median 41), the youngest was an 11-year old male and the oldest was an 86-year old female. Of the 102 cases, 33 had negative toxicology while 69 cases had at least one positive toxicology result. Females were equally likely to have negative or positive results (12 and 13 cases respectively), but males were 37.5% more likely to have positive toxicology ($n = 56$) rather than negative toxicology ($n = 21$). For females, alcohol, mirtazapine, venlafaxine, and trazodone were the top psychoactive substances in peripheral blood while THC, cocaine, hydrocodone, bupropion, olanzapine, doxylamine, quetiapine and dextromethorphan were also reported. For males, alcohol, THC, cocaine, amphetamine, methamphetamine, bupropion, and diphenhydramine were the top psychoactive substances in blood, but several other drugs were also found in individual cases. Our study of hanging cases over a 3-year period support the idea that complete postmortem toxicology investigation of hangings should be performed, even when the "obvious" cause of death is asphyxia due to hanging. Many of these cases involved psychoactive substances (most often alcohol and cannabis), and having such knowledge provides a better understanding of the circumstances surrounding the decedent's death, their possible state of impairment, including the possibility of a staged suicide if the decedent was too impaired to perform a self-hanging.

1. Introduction

Suicides by hanging/suffocation in the United States of America have increased by 52% from 2000 to 2010 [1]. An estimated 804,000 suicides occur annually worldwide, and suicide is the second leading cause of death for persons between the ages of 15 and 29 [2]. Notwithstanding, in some jurisdictions biological specimens are not always collected and toxicology studies are not ordered or undertaken by some coroners, medical examiners, forensic toxicologists, and other persons involved in the investigation of these deaths because the cause of death seems "obvious" and the additional work and associated analytical studies are considered by some as inappropriate use of their limited funds that may cause delays and may contribute little to the final determination of cause and manner of death.

Toxicologic analyses of blood and urine, however, provide relevant and useful information that contribute to the understanding of the totality of events when considering sudden, violent, or suspicious deaths. Hanging cases (frequently suicides, although sometimes accidental or homicidal) can be especially complex due to the varied demographic, psychological, and physiologic variations of decedents in these cases. In Greece, for example, prisoners in a correctional facility who were unemployed, single, without children, and/or had a history of drug abuse, were determined to be the most likely individuals to commit suicide, 45% of which were by hanging [3]. Cultural values can also affect which ethnicities are more likely to commit suicide by hanging as a recent Australian study found [4]. Similarly, suicide by hanging was determined to

* Corresponding author. Tel.: +1 415 553 9009; fax: +1 415 553 9815.
E-mail address: nikolas.lemos@sfgov.org (N.P. Lemos).

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be the second most prevalent method of death for Native Americans in the United States of America, with a rate 2.5 times higher than the national average [5]. In a Brazilian study, approximately 37.5% of hanging cases had positive blood alcohol content [6], and in Sweden positive toxicology results were found in 67% of all hanging cases and ethanol was present at higher concentrations in hanging cases than in suicides-by-overdose [7]. A large portion of deaths by hanging were also found to involve ethanol or other drugs, and, in many cases, men were far more likely to commit suicide by hanging (from approximately 7:1 to approximately 8:1) than women [3,4,6–8]. In Turkey, a study focusing on 13 deaths by hanging in children reported that 'when the toxicological analyses were performed, no substance was discovered...' but fail to report exactly how many of the 13 deaths had actually undergone toxicology studies or how wide the scope of any undertaken toxicology screening actually was [9]. In a recent nationwide study in the USA, ethanol was found in approximately one-third of hanging cases, and was more likely to be found in younger individuals [10]. These findings appear to be in agreement with a study of hanging deaths in Portugal which also found that ethanol was likely to be found more frequently in hangings than in other methods of suicide [11].

San Francisco is a large American city situated on the pacific coast of the country occupied by a relatively young, educated, and multi-cultural population. Females comprise 49.1% of the population 52.0% of which are educated at Bachelor's degree or higher. An estimated 4.6% of San Franciscans are persons under 5 years, 13.4% are persons under 18 years and 14.2% are persons 65 years and over. Racially, in 2013 San Francisco comprised 41.6% Whites, 34.4% Asians, 15.3% Hispanics and 6.0% Blacks according to the US Census Bureau. The aim of the present study is to examine deaths by hanging including their demographic and toxicologic information in the diverse metropolis of San Francisco between 2011 and 2013. We hypothesize that useful information can be extracted from toxicology studies performed in these cases that can complement scene and autopsy findings and shed additional light to the circumstances surrounding these deaths.

2. Materials and methods

The Forensic Laboratory Division (FLD) of the San Francisco Office of the Chief Medical Examiner (OCME) performs toxicologic analyses on behalf of various law enforcement agencies that operate within the City and County of San Francisco. Cardiac/central blood (BL-C) and peripheral blood (BL-P) are typically drawn into BD Vacutainer® test tubes (Becton Dickinson and Company, Franklin Lakes, FL) by a board-certified medical examiner during autopsy and submitted to the Laboratory Division for testing. Vitreous Humor (VH) and urine (UR), if available, are collected and submitted in glass test tubes or jars, respectively. Autopsies normally take place on the next business day following the death and decedents are normally refrigerated until the time of autopsy.

Submitted BL-P and VH specimens undergo duplicate small-volatile determinations for the presence and quantity of ethanol, methanol, acetone and isopropanol. The duplicate analyses are carried out by gas chromatography using flame ionization detectors (GC–FID) and headspace auto-samplers in compliance with California Code of Regulations, Title 17, Group 8, §1215–1222.

Specimens are next screened for drugs by Enzyme Linked Immunosorbent Assay (ELISA) using commercially available ELISA kits (Venture Labs Inc., Redwood City, CA, USA) as well by full scan gas chromatography coupled with mass spectrometry (GC–MS) by Agilent Technologies (Santa Clara, CA, USA) for over one hundred drugs and metabolites. Typically, the drug screens by ELISA and GC–MS are performed on BL-C and UR specimens. Table 1 presents the manufacturer-recommended ELISA cut-off concentrations for blood and urine specimens for cocaine, amphetamines, barbiturates, benzodiazepines, cannabinoids, fentanyl, methadone, tricyclic antidepressants, opiates, oxycodone and phencyclidine. Presumptive positive ELISA or GC–MS results are followed by confirmation and/or quantitation in a fresh aliquot of BL-P or UR using GC–MS or liquid chromatography coupled with tandem mass spectrometry (LC–MS/MS) as dictated by the chemical and physical properties of the drug or drugs presumed present in the specimens.

Table 1
Cut-off concentrations for blood and urine drug screening by ELISA in all post-mortem cases (including those of suspected hanging) that come under the jurisdiction of the Office of the Chief Medical Examiner.

Drug or class of drugs	Blood cut-off concentration (ng/mL)	Urine cut-off concentration (ng/mL)
Amphetamine	50	300
Barbiturates	20	300
Benzodiazepines	20	300
Cannabinoids	5	50
Cocaine	20	300
Fentanyl	0.25	0.5
Methadone	20	300
Methamphetamine	50	300
Opiates	10	300
Oxycodone	20	300
Phencyclidine	10	50

Upon completion of all analytical tests including alcohol and related compounds by GC–FID, drugs screens by ELISA, GC–MS and drug confirmations/quantitations by GC–MS and/or LC–MS/MS as needed, the case file is reviewed by a board-certified forensic toxicologist in light of the case history and all other available information and a toxicology report is issued to the case medical examiner who eventually certifies the cause and manner of death.

Our study retrospectively reviewed the in-house databases used by the Forensic Laboratory Division and the Medical Division of the OCME in order to access, review, and tabulate demographic and toxicologic information for all hanging cases that came under the jurisdiction of this Office from January 2011 to December 2013 using commercially available spreadsheet computer software (Microsoft, Redmond, WA).

3. Results

Our retrospective review of the medical and forensic laboratory division databases revealed that the SF OCME assumed jurisdiction in 3912 cases in the period from January 2011 to December 2013 and that 102 of these cases (2.6%) were hangings. Of the 102 hangings, 99 were determined to be suicides comprising 30.4% of the total number of suicides ($n = 326$) investigated in the same time period (Fig. 1a). Table 2 presents demographic and toxicologic details of the 102 hanging cases which occurred in the City and County of San Francisco during the time period of interest.

The 102 hangings pertained to 25 females and 77 males (Fig. 1b) which were distributed approximately equally among the three calendar years (Fig. 1c) and which were determined to be suicides in their vast majority with two accidental and one undetermined case (Fig. 1d).

Of the 102 cases, 33 had negative toxicology reports while 69 cases had at least one positive toxicology result listed on the toxicology report issued by the Forensic Laboratory Division (Fig. 2a). The racial distribution among the 102 hangings showed that 60% of these decedents were White with 21% being Asian, 8% being Hispanic and 6% being Black (Fig. 2b).

When examined for monthly, seasonal and site-of-incident variations, the 102 hanging deaths showed (a) wide distribution in