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Bodies Found in the Waterways of New York City

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ABSTRACT: We reviewed the case records for all decedents recovered from the waterways of New York City over a three year period (1997–2000). The epidemiological profile, circumstances, toxicology findings, putrefactive changes, date of recovery, length of immersion, and injuries were examined. There were 123 deaths: 52 suicides, 50 undetermined, 16 accidents, and five homicides. The causes of death included: 97 drownings, 13 undetermined, and 13 other. Of all the floating decedents, 27% were without putrefactive change. All found after two or more weeks of immersion were recovered from November to May. The detection of ethanol and illicit drugs was 53% in the accident, 41% in the suicide, and 33% in the undetermined groups. Detection of ethanol and/or drugs of abuse is not a reliable criterion to distinguish suicide from accident. The identification of the deceased is pivotal for determining the manner of these deaths. Therefore, a great reliance is placed upon the medical investigator and the police (including the missing persons bureau) to determine the circumstances and identification of the decedent.

KEYWORDS: forensic science, forensic pathology, drowning, manner of death, toxicology, New York City

Decedents recovered from water present several challenges to the death investigator. Drowning is a diagnosis based upon the circumstances surrounding the death and the exclusion of other causes of death. In addition to a complete autopsy with toxicologic studies, the circumstances and often the medical history of the decedent are needed for proper death certification. The key to unlocking this information begins with the identification of the deceased.

We reviewed the case records for all decedents recovered from the waterways of New York City that underwent autopsy at the Office of Chief Medical Examiner of the City of New York over a three year period (1997 to 2000). The epidemiological profile, circumstances, toxicology findings, degree of putrefactive change, date of recovery, length of immersion, and injuries were examined. The identification of the decedent is critical for proper certification of the cause and manner of these deaths. Putrefaction is a common finding in these deaths and hinders identification, the interpretation of injuries, and the determination of postmortem interval. Unlike most death investigations, examination of the scene is not as helpful. The effects of the "scene" on the body, however, are important. The effects of water and climate over time on the decedent and the benefits and pitfalls of toxicologic testing for death certification are examined.

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Materials and Methods

The Office of Chief Medical Examiner investigates all unexpected, violent, and suspicious deaths in the five boroughs that comprise New York City. This study was conducted on all fatalities found in the waterways of New York City. Swimming pools and bathtubs were excluded. There were no SCUBA deaths. Autopsies with toxicologic testing are routinely performed on violent deaths.

All decedents found in the waterways of New York City that underwent autopsy from January 1997 to January 2000 were identified through the New York City Office of Chief Medical Examiner (OCME) database using a textword search for "water," "floater," and "river." All case files were reviewed including: the autopsy, toxicology, and investigator's report. In select instances, police reports, scene and autopsy photographs/diagrams, and medical records were reviewed. The age, race, sex, dates found and last seen, degree of putrefaction, injuries, circumstances, medical history, location, toxicology results, and cause and manner of death were extracted. Putrefaction was graded as: "none, slight, moderate, and marked" based on a previously described standard (1).

Toxicological testing was performed on all but two deaths. Specimens routinely collected for toxicological analysis include: blood (peripheral preferred), urine, bile, vitreous humor, brain, liver, and gastric contents. Autopsy blood specimens were collected with addition of sodium fluoride and stored at 4°C. The toxicology laboratory at the Office of Chief Medical Examiner analyzed all specimens. Ethanol concentrations were determined in blood (and vitreous or urine if available) using head space gas chromatography. Acute ethanol intoxication was ascertained if: (a) ethanol was detected in the vitreous or urine in combination with a positive blood ethanol, (b) the blood ethanol was 0.20 g% or greater, or (c) the blood ethanol concentration was greater than 0.04 g% in any nonputrefied decedent.

Urine specimens were routinely tested for opiates, barbiturates, benzoylecgonine (BE), cannabinoids, amphetamines, phencyclidine, and methadone by enzyme immunoassay. In cases where urine was not available, blood was tested for opiates, benzoylecgonine, barbiturates, and cannabinoids using radioimmunoassay. Urine or blood was also screened for basic drugs (including ketamine and cocaine) by gas chromatography with a nitrogen phosphorous detector (GC/NPD).

All decedents with putrefactive changes were photographed, radiographed (head, chest, and teeth), and fingerprinted. Blood was retained for possible DNA analysis from all autopsies. We do not perform diatom or serum electrolyte testing in suspected deaths by drowning.

Results

There were 123 deaths: 52 suicides, 50 undetermined manner, 16 accidents, and 5 homicides. The causes of death included: 97

drownings, 13 undetermined, and 13 other (including blunt trauma and strangulations). The cause of death was determined in 89% and the manner in 59% of deaths. The age, race, and sex results by manner are listed in Table 1. Overall, the age range was 13 to 92 years with a mean of 42 years and there were more men than women (4.5 to 1). The identity was established in 72% of all decedents with the identification rate for accidents (100%) and suicides (98%) much higher than the undetermined (42%) and homicide (20%) manners. Visual recognition (67%) was the most common means of identification, followed by radiologic (19%), and fingerprint comparisons (14%). DNA comparisons were used and resulted in exclusion of identity.

The psychiatric and toxicological findings are presented in Table 2. The toxicological detection of psychiatric medications (26%) supports the high incidence of psychiatric illness (92%) in the suicide group. No psychiatric medication was detected in the accident group. Psychiatric disease was reported in 32% and psychiatric medication was detected in 12% of the undetermined manner group. No psychiatric history, however, was known in 60% of the undetermined group (most due to lack of identification). Antihistamines were detected in 10% of all suicides, 12% of the undetermined group, and in no accidents. Suicide notes were found in 15% of suicides, and an additional 6% verbally expressed a plan to commit suicide by drowning.

In the accident group, the detection of ethanol and illicit drugs was 53% compared with 41% in the suicide group and 33% in the undetermined group. Postmortem production of ethanol was ascertained in 53% and acute ethanol intoxication in 28% of all deaths. The percent of deaths by manner with an acute ethanol intoxication were: accident = 47% (mean BAC of 0.25 g%), undetermined = 27% (0.21 g%), and suicide = 25% (0.17g%). Free cocaine was detected in amounts from 0.1 to 1.8 mg/L in four cases of known immersions from 6 to 10 days.

There were 42 decedents without putrefactive changes, 28 of which were found floating (in salt water) and 14 found on the shore or recovered by divers. Of all the floating decedents, 27% were without putrefactive change. The number of deaths had a fairly even distribution by month and season (Table 3). The effects of putrefaction upon pulmonary findings and postmortem production of ethanol are reported in Table 4. Among the lung weights, 18% of the nonputrefied and 51% of the markedly putrefied deaths had combined lung weights below 1000 g.

In 70 instances, well-documented histories or circumstances provided reliable information about when the person was last known to be alive. Of these cases, the time range of immersion to recovery was from minutes to 97 days. The majority of decedents showed putrefactive changes by Day 3 or 4. After two weeks, there were four with slight, 11 with moderate, and eight with marked putrefactive changes. Adipocere was seen in two decedents with known immersion durations (32 and 97 days). All found after two or more weeks of immersion were recovered from November to May (Fig. 1). The average monthly water temperatures are provided in Table 3.

TABLE 1—*Summary of cause of death and identification.*

	Total	Identified*
Cause of death		
Drowning	97 (79%)	76 (78%)
Undetermined	13 (11%)	0
Drowning and blunt injury	6	6 (100%)
Blung injury	4	2 (50%)
Neck compression	2	0
Neck compression and blunt	1	1 (100%)
Age range, yrs (mean)	13–92 (42)	NA
Men: women	82%:18%	NA
White: Black: Asian	60%:12%:28%	NA

* Decedent identity confirmed visually or by radiographic or fingerprint comparisons.

TABLE 2—*Demographic, psychiatric history, and toxicologic findings by manner.*

	Suicide	Undetermined	Accident	Homicide
Manner	52 (42%)	50 (41%)	16 (13%)	5 (4%)
Identified decedent	51 (98%)	21 (42%)	16 (100%)	1 (20%)
Age range (years)	17–92	18–57	13–84	19
Mean (years)	42	37	50	19*
Men:Women (%)	77:23	88:12	94:6	40:60
White: Black: Asian (%)	60:19:21	44:49:7	94:6:0	75:25:0
Psychiatric illness†	45 (92%)	16 (32%)	0	0
Positive toxicology‡	31 (61%)	23 (47%)	9 (60%)	1
Psychiatric medications	13 (26%)	6 (12%)	0	0
Ethanol/illicit drugs	21 (41%)	16 (33%)	8 (53%)	1
Sedative-hypnotics	4/51 (8%)	1/49 (2%)	0	0
Antidepressants	12/51 (24%)	4/49 (8%)	0	0
Antipsychotics	1/51 (2%)	1/49 (2%)	0	0
Ethanol, acute intoxication (%)	13/51 (26%)	13/49 (27%)	7/15 (47%)	0
Blood alcohol concentration, g% (mean)	0.05–0.36 (0.17)	0.1–0.39 (0.21)	0.02–0.41(0.25)	0
Cocaine or BE in blood (%)	9/51 (18%)	8/49 (16%)	2/15 (13%)	0
Antihistamines	5/51 (10%)	6 (12%)	0	1 (20%)

* Single known age.
† Including chronic substance abuse.
‡ Three not tested.

TABLE 3—*Seasonal effects and putrefaction.*

Season	All (% Putrefied)	Mean Water Temperature Ranges (°F)	
December, January, February	21 (62%)	36–43	
March, April, May	36 (78%)	41–60	
June, July, August	35 (57%)	64–73	
September, October, November	31 (65%)	53–73	
Immersion duration*	**All (% Putrefied)**	**Nov.-May**	**June-Oct†**
<3 Days	29 (3%)	41%	59%
3–14 Days	18 (89%)	33%	66%
>14 Days	23 (100%)	100%	0%
Location found	**All (% Putrefied)**		
Shore	17 (29%)		
Floating	104 (73%)		
Recovered by divers	*2 (0%)*		
Total	123 (66%)		

* Of 70 known instances.

† Months decedents recovered (November through May and June through October).

TABLE 4—*Putrefaction effects on lung weights and postmortem ethanol production.*

Putrefaction	Mean Lung Weights*	Range of Lung Weights*	Mean Blood Ethanol†
None	1439	720–2740	0.001
Slight	1125	550–2590	0.03
Moderate	1120	440–2150	0.05
Marked	1049	380–1900	0.05

* Combined (right and left) lung weights, g.

† Concentration of postmortem blood ethanol production, g%.

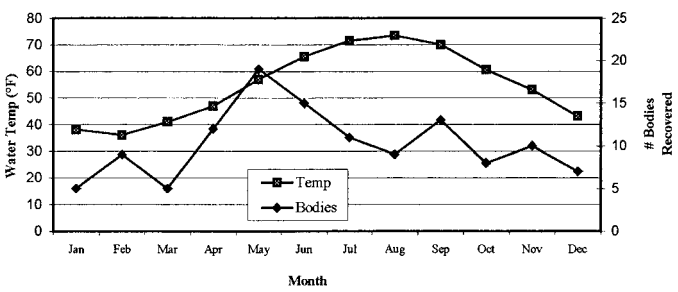

FIG. 1—*Bodies recovered by month versus water temperature by month.*

Discussion

New York City is surrounded by waterways (rivers, an ocean, and estuaries). Accordingly, there were 123 deaths recovered from bodies of water in a three year period. We examined the demographics, toxicology, postmortem changes, seasonal affects, and investigations of these deaths. Many have searched for pathologic or chemical changes to diagnose drowning at autopsy (2–6). Drowning remains a diagnosis of exclusion that relies heavily upon the circumstances of the death and a complete autopsy. Submersion or anatomic findings due to submersion, do not equate with death caused by submersion.

Pulmonary edema/fluid and the resultant airway foam seen in many drownings is neither specific nor sensitive (4,5,7). Pulmonary edema may be seen with deaths due to primary cardiac disease, acute intoxications (especially opiates), and seizures (neurogenic mechanism). Conversely, 10 to 20% of nonputrefied drowning deaths have "dry lungs" (i.e., the combined weight of the lungs, an indicator of pulmonary edema/fluid, is below 1000 g) (4). In our nonputrefied deaths, 17% of the decedents had "dry lungs" which is similar to a study by Copeland (4). However, in our markedly putrefied group, the percentage with "dry lungs" increased to 51%. There is a broad range of weights with substantial overlap among the groups (Table 4). Overall, the mean lung weights decrease with increasing extent of putrefaction.

Diatoms (algae with a silicaceous exoskeleton) and serum electrolyte concentrations have been used as adjunctive tests in suspected drownings. Due to the ubiquitous nature of diatoms, their detection is not conclusive of death by drowning. Even morphologic comparisons of recovered body diatoms with presumed source water diatoms lack statistical diatom population data and appropriately blinded and controlled studies (8). Serum electrolyte analysis is unreliable to establish a diagnosis of death by drowning (6).

The identity of the deceased is essential for determining the manner of these water deaths. Among unidentified individuals, 97% were certified as undetermined *manner* compared with 25% in the identified group. Among the unidentified without mechanical trauma, 30% were certified as undetermined *cause* compared with 5% in the identified group. All 13 deaths with an undetermined cause of death also had an undetermined manner.

Since drowning has no pathognomonic autopsy findings, the certification of the cause of death is dependent upon the circumstances and the exclusion of other causes. An unidentified person found in water without visible injury, is more likely to be certified with an undetermined manner than an undetermined cause of death. Decedents found in water may have some degree of trauma that is usually minor and noncontributory. Falls from heights into water, however, may result in blunt injuries that cause or contribute to death. Deaths due to homicidal violence that are subsequently found in water are less dependent on the identification of the decedent and circumstances for the certification of death.

Without an identification of the decedent, the only clues to a possible psychiatric/suicide history are medications found in the postmortem toxicologic analysis or self-inflicted injuries (e.g., incised or scarred wrists). Several of the undetermined manner deaths had findings suggestive of suicide such as the detection of certain medications (antidepressants, antihistamines) or horizontal wrist scars. The failure to identify the deceased and discover the resultant plethora of psychiatric, personal, and medical details, resulted in an undetermined manner of death.

In his reviews of bodies found in water, Davis emphasized that the identification and the circumstances surrounding the death are as important if not more important than the autopsy to determine the cause and manner of death (7). Human, environmental, and equipment factors must be evaluated (9). Accordingly, a great reliance is placed upon the medical investigator and the police (including the missing person's bureau) for a diligent search for the circumstances of the death and the identification of the deceased.

Ethanol and/or illicit drugs were found in 53% of accidents, 41% of suicides, and 33% of undetermined deaths. Detection of ethanol

or drugs of abuse is not a reliable criterion to distinguish suicide from accident. The increased risk of drowning when recreational water activities are mixed with ethanol is well known (7,10,11). Pachar detected ethanol in 44% of submersion deaths but these were not divided by manner (12).

Psychiatric medications were detected in 25% of the suicides, 12% of the undetermined deaths, and none of the accidents. The toxicologic detection of psychiatric medications may verify or establish a history of major depression. The detection of psychiatric medication at appropriate therapeutic concentrations is insufficient by itself to make a determination of suicide. The detection of antidepressant medication is not always synonymous with depression. Several "antidepressant" medications are used for nondepressive illnesses: migraines, premenstrual syndrome, epilepsy, etc. Detection of certain nonpsychiatric medications also may support a manner of suicide. For example, antihistamines were detected in 10% of suicides and no accidents (13). Their prevalence may be related to sleep disturbances among the depressed (14,15) or may be a failed attempt at suicide by ingestion. No suicides had elevated concentrations of salicylates or acetaminophen. Of those in the group of undetermined manners, antihistamines were detected in six (12%) and psychiatric medications in five (10%) suggesting that this group included some suicides. Of these five, four were not identified and one did not have a psychiatric history. Since suicide is the only manner of death that requires the demonstration of intent by the decedent, it is one of the most arduous deaths to certify.

The percentage of suicides in which psychiatric medications were detected in New York City (25%) was similar to those of Copeland (28%), Davis (21%), and Avis (17%) (13,16,17). Compared with the New York rates, ethanol detection in other studies of drownings have reported similar, higher, and lower rates (7,16,17). Postmortem production of ethanol and the challenge of properly collecting and interpreting the data, may account for these variations. Detection of illicit drugs has been previously reported in 0 to 8% of drowning suicides compared to 24% in New York (13,16). These differences may be a reflection of the regional age differences of the decedents and substance abuse patterns in New York City. Of note, even though cocaine undergoes spontaneous postmortem hydrolysis to benzoylecgonine, cocaine was still detected in deaths with a known postmortem interval of greater than 6 days.

The decedents were recovered throughout the year with an average monthly range of two (January) to just over six (May). Most decedents were recovered in the spring. A study in London, which has a comparable climate to New York City, found a similar distribution throughout the year with the greatest numbers recovered in May and June (12). The average monthly temperature of the water surrounding Manhattan ranges from 74°F (August) to 36°F (February) with a decrease to the 50s in October and an increase to the 60s in May. Figure 1 shows a comparison of water temperature and the number of decedents recovered by month. There is a peak in recovered decedents in the spring (as the water temperature increases) and a decrease in the late autumn (as the water temperature drops). Accidents due to seasonal recreational activities are unlikely to explain this peak. Accidents only make up 22% of deaths with a determined manner and the cold water in the spring makes swimming prohibitive. Of the deaths with known immersion dates, all recovered in the winter and spring had been in the water for greater than two weeks and all recovered between June and October had been in the water for fewer than eight days. This is a result of slower putrefaction due to colder water temperatures.

Since the extent of decomposition is dependent on many variables including the environment, one is unable to precisely state how long a body has been immersed based upon the degree of putrefaction. A body does not float until its specific gravity reaches the point of buoyancy. Bloating, due to postmortem bacterial gas production, lowers the specific gravity and brings the body to the water surface which allows for easier discovery and recovery. However, in our study of 123 decedents, 42 (34%) were free of putrefactive change (28 found floating, 12 found on shore, and 2 recovered by divers). Investigators of missing persons must be aware of the longer immersion times of decedents recovered in the winter and spring so as not to exclude a possible match based upon chronology.

The majority of deaths were men (4:1) which is similar to other studies on drownings (12,13,16,17). One study from Finland was comprised of almost equal numbers of men and women (18). The majority of deaths (69%) were between the ages of 21 and 50 years. Pachar had a similar peak in the younger age groups (12). The age distribution of the suicides was similar to Auer's findings (18) with 75% of the cases between 21 and 50 years and a small peak in the 70+ years group. Other studies, however, have found the majority of suicides by drowning to be over 50 years of age (13,16,17). These age and sex differences may be representative of different local demographics of New York City and those regions of the other studies.

In summary, there is no single scene, autopsy, psychiatric, or toxicologic finding that can consistently and reliably be used to certify these deaths. This study describes certain findings that, when used in the context of a complete death investigation, may further help to support or refute a particular manner of death. Toxicologic findings may aid in the certification process but must not be interpreted out of context. These findings, compared with other regions, reveal differences in toxicological profiles and demographics. One must be cognizant of the role of decomposition and of seasonal water effects during the investigation and identification processes. The identification of the decedent is crucial and is where the primary effort should be expended. Areas with limited resources, would be best served by concentrating their resources on the identification of the deceased in addition to an autopsy with toxicologic examination.

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