Forensic Science International 231 (2013) 399.e1–399.e5

Contents lists available at SciVerse ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Forensic Anthropology Population Data

Patterns of skeletal trauma in suicidal bridge jumpers: A retrospective study from the southeastern United States

Suzanne M. Abel *, Scott Ramsey [1]

Charleston County Coroner's Office, 4050 Bridgeview Drive, Perimeter Center, Suite 500, North Charleston, SC, USA

ARTICLE INFO

Article history:
Received 3 January 2013
Received in revised form 5 March 2013
Accepted 16 May 2013
Available online 24 June 2013

Keywords:
Skeletal trauma
Suicide
Bridges
Fractures

ABSTRACT

In the discovery of human remains from water environments, manner of death may not be immediately obvious to medicolegal investigators due to several factors, including lack of associated material evidence, nondescript contextual environment, or possible poor preservation of remains due to delayed recovery. The determination of patterns of skeletal trauma in suicidal bridge jumpers assists investigators in determining whether the manner of death was suicide versus non-suicide. This study reports on the patterns of skeletal trauma sustained in individuals who jumped from one of four large bridges in Charleston Harbor, South Carolina, and explores victim demographics, bridge height, position of the body upon impact, and velocity at impact on skeletal trauma for this suicide population. Data for all bridge jumpers were collected from coroner files spanning the years 1990–2011. Skeletal trauma is more heavily focused in the thorax/ribs (63%) and craniofacial (30%) regions. Fifty-six percent of jumpers sustained polytrauma. Comparative data on drowning victims, bodies recovered from boating/airplane accidents, and individuals who died by other suicidal means all show patterns of injury different than bridge jumpers.

1. Introduction

Upon recovery of human remains from water contexts, the coroner/medical examiner will routinely work cases where an individual's death may have resulted from numerous scenarios such as accidental drownings, boating accidents, falling/dumping into water after homicidal/suicidal activities, or intentional jumps from nearby bridges. Manner of death may not be immediately obvious due to the scene context and/or poor preservation due to delayed recovery. Given these challenges, medicolegal investigators are charged with determining manner of death through subsequent scene investigation and through soft and hard tissue evidence gleaned from physical remains.

Rapid decomposition (i.e., marbling, bloating, and organ liquefaction) resulting from deposition in temperate waters often hinders the use of soft tissue markers that may assist in the determination of manner of death. In these cases, skeletal markers become more useful in determining the circumstances surrounding the death event. It is therefore important that forensic investigators try to determine if there exists a pattern of skeletal injury to bridge jumpers so that these individuals can be differentiated from those who ended up in the water by means other than intentionally jumping from one of the bridges.

Prior studies on trauma resulting from suicidal bridge jumping have ranged from general observations of demographic variables and overviews of injuries sustained [1,2], to multi-factorial studies exploring the causes of soft and hard tissue trauma that follow impact with water [3,4]. Bridge height [5–7], velocity at impact [4], and body orientation at impact [8–10], are offered as biomechanical factors that influence trauma patterns in such suicides. Biological variables such as sex, age, and ancestry of known jumpers should be taken into consideration as possible factors that influence the distribution of trauma. The possible influence of extrinsic, population-specific behavioral tendencies may also play a part in the frequency and expression of suicidal bridge jumping.

This study reports on the patterns of skeletal trauma sustained by individuals who jumped from one of four large bridges in Charleston Harbor and explores victim demographics, bridge height, body orientation and velocity at impact on skeletal trauma for this suicide population.

Charleston Harbor is an 8-square-mile inlet off the Atlantic Ocean in Charleston, South Carolina. The inlet is formed by the confluence of the Ashley and Cooper Rivers at latitude 32–45′50″ N, longitude 079–53′50″ W. The city has a total land area of 97.0 square miles and includes 17.1 square miles of water. There

* Corresponding author. Tel.: +1 843 746 4030.
E-mail addresses: sabel@charlestoncounty.org, sabel123@hotmail.com (S.M. Abel), sramsey@charlestoncounty.org (S. Ramsey).
[1] Tel.: +1 843 746 4030.

0379-0738/$ – see front matter © 2013 Elsevier Ireland Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.forsciint.2013.05.034

are 21 nautical miles of waterfront in the harbor and 40 nautical miles of waterfront included in the City of Charleston [11]. Several bridges are located in the harbor and connect peninsular Charleston to the mainlands in the east and west. Due to the substantial water mass that surrounds the peninsula, it is not surprising that the Coroner's Office investigates numerous fatalities in and around water every year, many of which are suicides by jumping from one of several large bridges in the harbor.

The temperate waters of Charleston Harbor range from 50°F to 84°F [12] and bodies in the water will begin a visible decomposition process relatively quickly. Bodies that remain unrecovered in the water for a period as brief as two days will show extensive bloating, marbling and skin sloughing. Any amount of time longer than 2–3 days results in significant organ liquefaction, especially if the body is recovered in the upriver marshes where lower salinity levels and shallow waters accelerate the decomposition process [13]. Such levels of soft tissue decomposition hinder identification and obscure evidence of external trauma that may lead to indications of cause and manner of death. In these instances, the skeletal components are the only areas to retain clues for identification and cause and manner of death for those who died on impact with water or soon thereafter.

2. Materials and methods

Data on bridge jumpers were collected from coroner files spanning the years 1990–2011. These files include demographic statistics, investigative narratives, witness statements, and pathology reports for all decedents. From these files, data on sex, age, ancestry of the victim and skeletal trauma were collected. Any observable trauma to remaining soft tissue documented at autopsy was noted to estimate body orientation at impact. Specific information includes demographics, location and extent of soft and hard tissue injury, and cause of death. Soft tissue injuries were categorized to include location (craniofacial, thoracic, upper appendicular, lower appendicular), side (anterior, posterior, right, left) and probable impact direction (vertical, horizontal). Skeletal trauma was categorized to include specific element and side. To facilitate statistical analyses, skeletal injury was also regionally categorized into craniofacial, thoracic, upper appendicular, and lower appendicular.

Jumpers from the four main bridges in the eastern portion of Charleston Harbor are considered in this study due to their similar heights, focused location, and equal access to jumpers (Table 1). The Ravenel Bridge is a 2.5-mile long, eight-lane, cable-stayed bridge constructed in 2005 to replace two smaller, aging cantilever structures. The 1929 Grace Memorial Bridge and 1966 Silas Pearman Bridge both spanned the shipping channel between the city of Charleston and the town of Mount Pleasant. The distance between the rail of the Ravenel Bridge to the water is 186 feet at mid-span. The two smaller Grace and Pearman Bridges were adjacent, separate spans for one-way travel in opposite directions, each with a distance between the rail and water of 155 feet at mid-span. The final structure is the 1992 Don Holt Bridge, a truss bridge also with a clearance of 155 feet at mid span. This bridge provides a connection between the communities east of the Cooper River, including North Charleston and Mount Pleasant.

To explore the relevance and comparability of kinetic data to other studies, velocity at impact was calculated using the equation

$$v = \sqrt{2}gh$$

where v = the velocity at impact, g is the gravitational constant of 9.8 m/s^2 and h is the vertical distance of the fall. The effect of aerodynamic drag, while acknowledged, is inconsequential in most cases of human free fall [14] and therefore was not calculated.

Table 1
The maximum clearance, frequency/percentage of jumpers, and impact velocity for the bridges used in this study.

Bridge	Maximum Clearance		Frequency/ Percentage of jumpers		Impact velocity	
Ravenel	186 ft	57 m	6	22%	74 mph	119 km/h
Grace Memorial	155 ft	47 m	3	11%	68 mph	109 km/h
Silas Pearman	155 ft	47 m	12	44%	68 mph	109 km/h
Don Holt	155 ft	47 m	6	22%	68 mph	109 km/h

3. Results

From 1990 to 2011, a total of 29 individuals succeeded in committing suicide by jumping from the four bridges located in Charleston Harbor. Suicide as a manner of death was attributed to all 29 since they were either observed jumping intentionally from the bridge or because suicide notes were left behind suggesting their intent on jumping from a bridge. The majority of jumpers also had extensive psychiatric records indicating histories of suicidal ideation. Two of these individuals landed not in the water but rather on intermediary structures located directly underneath and were not included in this study. Demographic statistics and recovery data are listed in Table 2.

Over 70% of the victims were white males. Individuals spanned in age from 18 to 64 years with the majority (37%) in the 41–50 year age group. Asphyxia due to drowning was the most common cause of death attributed in this sample (67%), followed by blunt chest (26%) and blunt head (7%) trauma. Autopsy reports indicate that these individuals died either directly upon impact or very shortly thereafter. Nearly 60% of the bodies were recovered from the harbor within 60 min of an observed jump. Those individuals not recovered for one or more days exhibited increased decomposition changes.

Observation of major trauma to remaining external soft tissue in the form of abrasions, lacerations, and contusions indicated primary water impact site (Table 3). For example, soft tissue trauma found on the posterior cranial vault, back, and posterior legs suggests the individual landed in the water in a more horizontal (supine) position. Soft tissue injuries found only on the more distal body regions (head, hands, wrists, or feet) suggests a vertical impact, either head-first or feet-first. Using the available external soft tissue indicators, it is determined that 63% landed in a horizontal position and 22% landed in a vertical position. Those who entered the water horizontally had the most amount of injuries while those who entered head- or feet-first had the least.

All bridge jumpers, regardless of specific cause of death, exhibited a pattern of skeletal injuries. Skeletal trauma is more heavily focused in the thorax (mostly ribs) (63%) and craniofacial (37%) regions. Rib fractures were equally distributed to the left and right sides and all were fractured serially, with no individual sustaining an isolated rib fracture. Vertebral fractures were observed in only 4 individuals. Fractures were seen throughout the cervical spine and upper thoracic elements; no fractures to the lumbar vertebrae were observed. Trauma to the upper appendicular skeleton was found in 18% of the sample. Trauma to the lower appendicular skeleton was found in 15% of the sample. Fifty-six percent of jumpers sustained polytrauma with more than one bone fractured.

4. Velocity at impact

Equations from dynamic physics, including velocity at impact, are used to estimate survivability in jumps from heights [4,8]. Injuries sustained after high velocity impacts with water will differ from those received from impact with solid surfaces such as soil or concrete. This is directly related to the deceleration capability of water and body orientation upon impact. Height of the jump will also play a significant role in survivability. Kurtz and colleagues [4] found that it was generally possible to survive a jump from a bridge up to approximately 41 m. Mortality significantly increases in bridge heights above this measure.

Over 77% of the bridge jumps in this study were witnessed. All witnesses reported seeing the victim jump from near the peak elevation of the bridges, so the maximum clearance distances were used in calculations of velocity at impact. Using the equation