Whitewater Rafting and Kayaking Deaths in Colorado: Increasing Preventative Measures By Understanding Risk Factors

Jarod Murdoch, Leon K. Kelly

ABSTRACT

Introduction: Whitewater rafting and kayaking are popular, adventurous excursions that are provided along various rivers throughout the United States. We expect that certain individuals' comorbid medical conditions may increase the risk of mortality by preventing them from being physically able to avoid inadvertently entering the water and subsequently rescue themselves.

Methods: Retrospective data were collected from 11 El Paso County, Colorado coroner cases from 2014-2017 in which the individual was whitewater rafting or kayaking and drowning was determined to be the primary cause of death.

Results: Health characteristics and autopsy findings of several of these individuals revealed that a significant number of these individuals were overweight or obese (90.9%), with 70% of these individuals also demonstrating cardiomegaly on examination. Of the cases studied, 81.8% of individuals had little to no experience with whitewater rafting or kayaking and 45% were under the influence of marijuana or alcohol based on toxicology studies.

Discussion: While a major selling point for whitewater excursions are the perceived risks they offer, our review suggests that certain individuals demonstrate increased health risks, have little to no experience with whitewater rafting or kayaking, or practice unsafe behaviors that may increase chance of injury and death. Efforts have been made to reduce risks associated with whitewater rafting and kayaking; however, further risk can be mitigated by excluding those who may be under the influence of alcohol or drugs, implementing more stringent health requirements, and setting an upper limit of difficulty of rapids based on an individual's previous experience. *Acad Forensic Pathol.* 2018 8(1): 44-49

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INTRODUCTION

Whitewater rafting and kayaking are popular, adventurous excursions that are provided along various rivers throughout the United States, drawing over 20 million participants per year (1). With these excursions, however, comes a small but inherent risk of injury and potential death. Colorado currently leads the nation in whitewater fatalities since 1975, accounting for 155 deaths and 13% of total fatalities in the United States due to whitewater excursions (2). Due to the risks associated with these excursions, personal protective equipment and trained professional accompaniment are recommended and, in most cases, required. However, whitewater rafting and kayaking also require exceptional physical exertion and we expect that mortality is amplified by certain individuals' comorbid medical conditions that either directly lead to death or significantly contribute to death by preventing them from being physically able to avoid inadvertently entering the water and subsequently rescue themselves.

METHODS

Retrospective data were acquired from 11 El Paso County, Colorado coroner cases from 2014-2017 in which the individual was whitewater rafting or kayaking and drowning was determined to be the primary cause of death. The cases were largely referred for autopsy from outside coroner agencies and often minimal investigative information such as water hazards, specific medical intervention, or cause of capsizing was available to the medical examiner. However,

each of the 11 individuals received full autopsies and individual demographic data, body mass index (BMI), significant medical history, and autopsy findings including specific internal pathology and injuries incurred during drowning were able to be collected. Lodox full body radiographic scans were performed on each death and reviewed by the medical examiner. Postmortem computed tomography (CT) scanning was not available in this jurisdiction. River rapid characteristics at the point of drowning were also collected and included rapid class, flow speed, and temperature of the water.

RESULTS

Time and Location of Death

Each of the individuals studied drowned along the Arkansas River in Colorado and each was noted to be wearing personal protective equipment, including a helmet, rescue vest, and wetsuit. Deaths occurred between April and June in each year studied with six (54.5%) of the cases occurring in 2014. Eight (72.7%) of these individuals were part of commercial excursions.

Rapid Characteristics

Rapid classes, flow rate, and temperature at the time of drowning were able to be extracted from 9 of 11 (81.8%) of the cases. The rapids ranged from class III to class V at the point of drowning. **Table 1** outlines characteristics of the different rapid classes. Flow rates

Table 1: Characteristics of Rapid Classes From Least to Most Advanced (3)

Rapid Class	Characteristics
I	Moving water with a few riffles and small waves. Few or no obstructions.
II	Easy rapids with smaller waves, clear channels that are obvious without scouting. Some maneuvering might be required.
III	Rapids with high, irregular waves. Narrow passages that often require precise maneuvering.
IV	Long, difficult rapids with constricted passages that often require complex maneuvering in turbulent water. The course may be hard to determine and scouting is often necessary.
V	Extremely difficult, long, and very violent rapids with tightly congested routes, which should be scouted from shore. Rescue conditions are difficult, and there is a significant hazard to life in the event of a mishap. The upper limit of what is possible in a commercial raft.
VI	Significantly advanced past Class V. Nearly impossible to navigate and very dangerous. For teams of experts only. Involves risk of life. Not commercially raftable.

ranged from 18.9 m³/s (674 ft³/s) to 70.1 m³/s (2520 ft³/s) with an average flow rate of 34.4 m³/s (1229 ft³/s). The water temperature ranged from 10–13°C (50–55°F) with an average temperature of 12.1°C (53.8°F).

Individual Characteristics

Seven (63.6%) of the individuals were male. The ages of the individuals ranged between 26–65 years with a mean age of 47.2 years. Weights and heights ranged between 77.1–138 kg (170–304 pounds) and 160–192 cm (63–75.5 in) in height, respectively, with averages of 107 kg (235.5 pounds) and 179 cm (70.4 in). Body mass index ranged from 24.0 to 41.2 kg/m² with an average of 33.6 kg/m². Six (54.5%) of the individuals came from other states, with one individual visiting from another country (India).

Previous Medical Conditions

Individuals' previously known medical conditions include one case of untreated sleep apnea and one with a previous left hip arthroplasty.

Injuries

Antemortem injuries were identified in seven individuals, predominantly consisting of minor contusions and lacerations of the extremities, with one individual exhibiting nonresuscitative rib fractures and one individual demonstrating a 200 mL right hemothorax.

Other Autopsy Findings

Significant autopsy findings included seven (63.6%) cases of cardiomegaly with an average heart weight of 507 g, and two (18.1%) cases of significant coronary artery atherosclerosis with stenosis of at least one of the vessels being greater than 70%. Other autopsy findings include hepatic steatosis (18.1%), granular kidneys (18.1%), minor to moderate granulomatous disease of lungs (9.1%), and myocardial fibrosis (36.4%).

Autopsy findings related to death in water include frothy pulmonary edema (36.4%); washerwoman

changes to the hands and feet (18.1%); severe congestion of the head, neck, and upper chest (18.1%); and excess sphenoid sinus fluid with gravel and sand in the upper airways (9.1%).

Toxicology

Postmortem toxicology studies revealed that four individuals had a qualitatively significant plasma concentration of tetrahydrocannabinol (THC) and one individual was found to have ethanol.

DISCUSSION

Popular destinations for whitewater adventures are scattered throughout the US, with the most popular centered in West Virginia, Massachusetts, Alaska, Arizona, Idaho, and Colorado. Each of these destinations provide areas that range from beginner to extremely advanced rapids. Specifically, in Colorado, the Arkansas River has rapids that range from class I–V along its length and may change suddenly from lower level rapids to more advanced.

A major selling point for whitewater rafting companies is the perceived risk that they offer. A recent study of 690 surveys of individuals taking part in these excursions have indicated that thrill and nature motivations lead to a positive affective response towards whitewater rafting and kayaking, which leads to an attachment to the adventure destination and positive behavioral outcomes. The study also revealed that perceived risk is a significant moderator between thrill and this affective response (4). It would stand to reason that by offering the opportunity to traverse more difficult rapids, it would increase the individual's experience and increase the chances to become a whitewater enthusiast, specifically through those companies offering a greater "thrill value" with less strict criteria. Eligibility criteria as referenced by several rafting organizations state that individuals participating in these excursions be in good general health and physical condition and wear protective recommended or required gear. Additionally, participants should be able to swim or be comfortable in the water, effectively communicate with leaders or other partic-

ipants, enter and exit a watercraft independently, and, in the event of capsize or fallout of watercraft, perform self-rescue or cooperate with assisted rescue (5, 6). These eligibility requirements are recommended and not strictly enforced as evidenced by a drowning victim within our study who was cited as being unable to swim but was still allowed to participate in the excursion. As well as these requirements, a participant's acknowledgement of risks or waiver form is required to be filled out, without requirement of disclosure of underlying health conditions. There is normally a minimum age and weight requirement; however, there is no maximum allowable age or weight for whitewater excursions (5, 6). Our study revealed that only two of the 11 decedents were uniquely qualified in whitewater rafting or kayaking, with one of these individuals being a whitewater kayak instructor and the other cited as having "extensive" whitewater rafting experience. The other individuals ranged from having no whitewater rafting or kayaking experience and being unable to swim to having minimal experience in rafting or kayaking. Based on the history retrieved, at least nine of these individuals drowned while attempting to navigate class III to class V rapids. While there is significant subjectivity to these ratings, class III to V rapids are considered to be advanced or expert level rapids (3).

A major finding while analyzing the health characteristics and autopsy findings of several of these individuals was that a significant number were overweight or obese (90.9%). Obesity is known to be an independent risk factor for cardiovascular disease, specifically coronary atherosclerosis, heart failure, atrial fibrillation, and even sudden cardiac death (7-9). Of these overweight and obese individuals, 70% were found to have corresponding cardiomegaly. Studies have shown that increased weight and adiposity correlates with left ventricular remodeling, hypertrophy, and overall worsening functional capacity of the heart (10). This decreased functional capacity is also compounded by the cardiac stress caused by cold water immersion. Cold shock is defined as the dynamic response of the body, including gasping, hyperventilation, increased cardiac output, peripheral vasoconstriction, and hy-

pertension evoked by cold receptors responding to the sudden decrease in skin temperature (11). This process starts in water measuring 25°C (77°F) and peaks between 10-15°C (50-59°F) (12). Most whitewater rivers nationwide are open for rafting and kayaking between May and September. However, based on our study, average water temperature at the time of drowning was 12°C (53.8°F), indicating restriction to these warmer months does not preclude these individuals from succumbing to cold shock. This worsening functional capacity combined with the body's response to immersion in cold water may have further compounded stress on the heart, potentially exposing the individual to develop a sudden, fatal arrhythmia.

Postmortem toxicology studies in these 11 deaths also revealed that 45% of these individuals were under the influence of alcohol or marijuana. The smallest amount of alcohol increases risk of drowning, and those with a blood alcohol concentration of 0.10 g/dL have about ten times the risk of death associated with recreational water-based activities compared to those who have not been drinking. This is because alcohol delays cognitive and central nervous system processing as well as affecting physiological responses, causing labyrinthine dysfunction and laryngospasm (13). Acute marijuana use has also been shown to cause cognitive blunting and delayed response time to complete certain tasks, both of which would directly affect the rapid mental processing necessary to traverse rapids and quick action needed to prevent oneself from drowning in the case of capsizing or fallout (14).

CONCLUSION

Efforts have been made in order to manage whitewater rafting and kayaking risk by suggesting the use of safety-oriented rafting outfitters who are responsive to safety concerns and have procedures to monitor on-river safety procedures (15). However, our study suggests that further risk can be mitigated by excluding those who may be under the influence of alcohol or drugs, implementing more stringent health requirements, and setting an upper limit of difficulty of rapids based on an individual's previous experience.

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