JOURNAL OF FORENSIC SCIENCES

J Forensic Sci, March 2011, Vol. 56, No. 2
doi: 10.1111/j.1556-4029.2010.01636.x
Available online at: onlinelibrary.wiley.com

CASE REPORT
PATHOLOGY/BIOLOGY

Russell T. Alexander,[1] *M.D. and Jeffrey M. Jentzen,*[2] *M.D.*

Neck and Scleral Hemorrhage in Drowning*

ABSTRACT: The determination of the cause and manner of death for a body recovered from the water can be difficult because of a lack of autopsy findings specific for drowning. This case report describes a 30-year-old man found submerged at the bottom of a hotel pool. An autopsy revealed scleral hemorrhages and fascial hemorrhages of multiple muscles of the anterior and posterior neck bilaterally. No evidence of traumatic injury was on the surface of the body. An investigation by law enforcement found no evidence of foul play. The occurrence of petechial and neck hemorrhage in a body recovered from the water is controversial, and a review of this literature will be given. We suggest that fascial hemorrhages of the muscles of the neck, as well as cephalic hemorrhages, can be explained by drowning-related elevated central venous pressure that is communicated to the head through the valveless veins of the neck.

KEYWORDS: forensic science, drowning, petechiae, hemorrhage, strap muscle, forensic pathology

Drowning has been defined as "death secondary to hypoxemia as a result of asphyxia while immersed in a liquid, usually water" (1, p. 846). Autopsy findings in drowning deaths are nonspecific, and the search for a postmortem "drowning test" has proved elusive (2). Several critical questions need to be answered by the investigation when a body is recovered from water. For example, how did the body come to be in the water? Was the decedent alive at the time that he or she entered the water? Was the body placed in the water after death in an attempt to conceal a homicide or other type of nondrowning death? If the person did drown, did any natural disease, drug intoxication, or environmental conditions contribute to the death? Consideration of autopsy findings, history, and scene investigation is critical for accurate certification of the death. This paper describes the occurrence of scleral and neck hemorrhages in a case of drowning and highlights the importance of not misinterpreting these findings as being diagnostic of an assault. A mechanism for the origin of drowning-related neck and cephalic hemorrhage will be suggested.

Case Report

Case History

A 30-year-old man and his 5-year-old stepson were found at the bottom of a hotel pool. Hotel cleaning personnel had gone to investigate the pool area at approximately 11:30 AM after seeing two apparently unattended young children, aged 1 and 3, "playing" on steps in the shallow end of the pool. The workers then saw two bodies lying face down at the bottom of the 9-foot deep end of the pool. Hotel staff pulled the unresponsive decedent and his stepson from the pool, while other workers escorted the two young children out of the area. The decedent reportedly had "blood" running out of his mouth and nose. At this time, his wife and daughter, who had just returned to the hotel from a haircut, responded to the scene as well. Although hotel staff stated that they immediately began cardiopulmonary resuscitation (CPR) on both victims, the wife said that she began CPR on her son and yelled for someone to start CPR on her husband without effect. Approximately 5 min after being dispatched, firefighters arrived at the scene and administered CPR to the decedent. The decedent was declared dead at the scene after 30 min of resuscitative efforts. A medical investigator responding to the scene noted a "foam cone" at the mouth and nose of the decedent (Fig. 1). A baggie containing a green leafy substance, later confirmed to be marijuana, was recovered from the swimsuit pocket of the decedent.

The stepson was taken in "critical" condition to a nearby children's hospital. The child was discharged the next day with no neurological deficits. At that time, he stated that the last thing he remembered was falling into the pool.

The decedent was last known to be alive when seen by his wife approximately 2.5 h earlier when she left the hotel. The wife stated that she did not know why he would go to the pool as neither he nor the children could swim. She thought that her husband and children had returned to their room to watch television. The wife did report, however, that the 5-year-old had expressed an interest in going to the pool the previous day. She also stated that her husband was in good health and did not take any prescription medications. He was described as happy and without psychiatric problems. She did not report that her husband abused illicit drugs. The pool area was secured and only accessible by use of a key card. Review of the door lock records revealed that a guest had used a key card to gain access to the pool area approximately 5–10 min prior to the time that the bodies were observed on the bottom of the pool. The door lock did not record which guest had opened the door. The decedent and his family had checked into the hotel the

[1]Office of the Chief Medical Examiner for the State of Maryland, 900 W. Baltimore Street, Baltimore, MD 21201.
[2]University of Michigan, 5226 Medical Science I, 1301 Catherine, Ann Arbor, MI 48109-5602.
*Presented at the 59th Annual Meeting of the American Academy of Forensic Sciences, February 19–24, 2007, in San Antonio, TX.

Received 9 Nov. 2009; and in revised form 6 Jan. 2010; accepted 23 Jan. 2010.

FIG. 1—*A ''foam cone'' was noted at the decedent's mouth and nose after he was pulled out of the pool.*

previous day after arriving from out of state to attend a family reunion. An investigation by law enforcement found no evidence to suggest foul play.

Autopsy Findings

At autopsy, a ''foam cone'' was at the mouth and nose. There were marked conjunctival and scleral hemorrhages bilaterally (Fig. 2). No abrasions or contusions were on the anterior or posterior neck, or elsewhere on the body. Internally, the lungs were hyperinflated, and frothy fluid filled the airways. The cut surfaces of the lung exuded foamy hemorrhagic fluid. The sphenoid sinus contained 3 mL of bloody fluid (Fig. 3). Blood was in the mastoid air cells bilaterally (Fig. 4). The right ventricle of the heart was dilated (Fig. 5). Otherwise, the 340 g heart had normally arising coronary arteries that exhibited an up to 25% luminal narrowing of the left anterior descending coronary artery by atherosclerosis.

A layered anterior neck dissection revealed patchy hemorrhage, up to 1.5 inches in diameter, on the surface of the sternocleidomastoid, sternohyoid, omohyoid, and cricothyroid muscles bilaterally (Fig. 6). This hemorrhage was confined to the fascial surfaces of the muscle, and sectioning did not reveal contusion within the

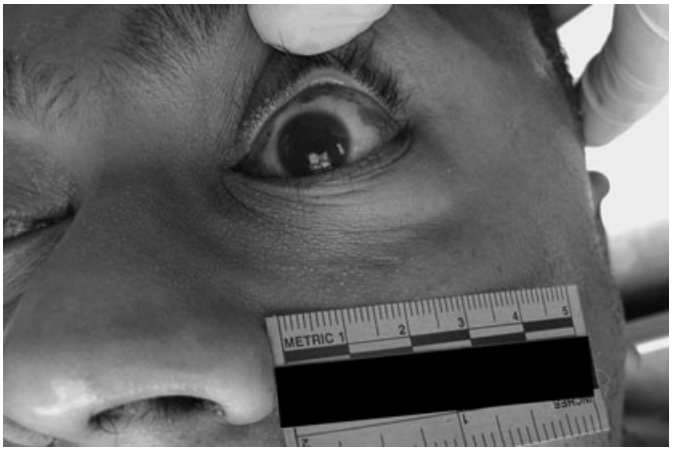

FIG. 2—*The decedent had scleral and conjunctival hemorrhage bilaterally.*

FIG. 3—*The sphenoid sinus contained 3 mL of bloody fluid.*

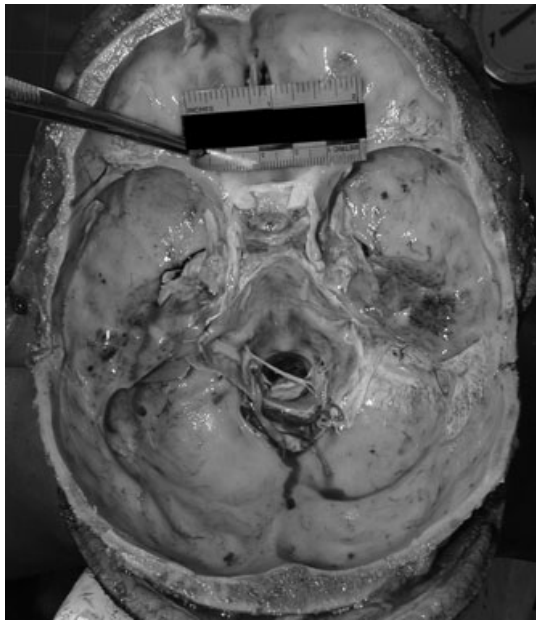

FIG. 4—*Blood was noted in the mastoid air cells bilaterally.*

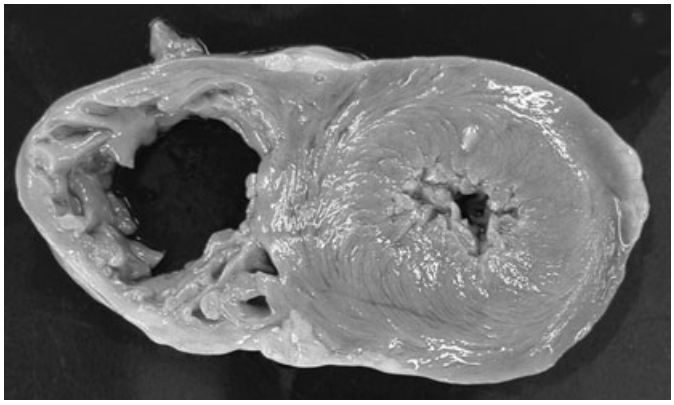

FIG. 5—*The right ventricle of the heart was dilated.*

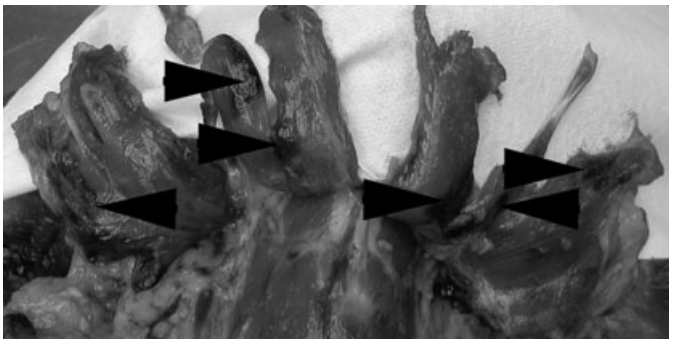

FIG. 6—*A layered anterior neck dissection revealed fascial hemorrhages within the sternocleidomastoid, sternohyoid, omohyoid, and cricothyroid muscles bilaterally (arrow heads).*

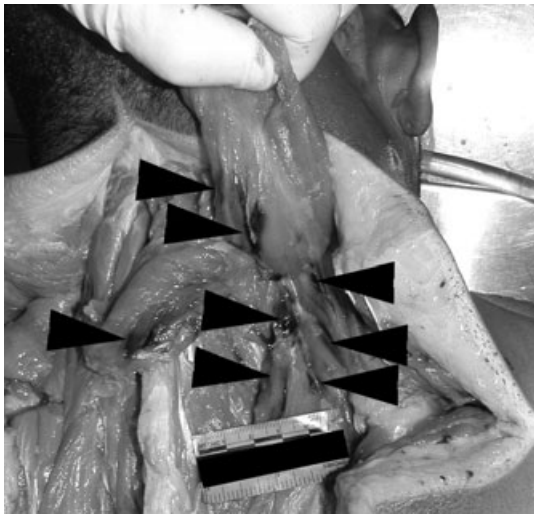

FIG. 7—*A posterior neck dissection revealed fascial hemorrhages within multiple muscles of the neck and upper back bilaterally (arrow heads).*

substance of the muscle. The thyroid gland was markedly congested. A posterior neck dissection revealed focal hemorrhage, up to 1.0 inch in diameter, on the fascial surfaces of the muscles of the upper back and neck bilaterally (Fig. 7).

A comprehensive toxicology screen obtained on iliac blood recovered at autopsy did not detect alcohol or any other drugs. A vitreous electrolyte screen was normal. The cause of death was certified as drowning. The manner of death was accident.

Discussion

When a body is discovered in water, possibilities include, in part, an unwitnessed drowning or homicide with subsequent placement of the body in the water. Autopsy findings for drowning are nonspecific and commonly include: immersion wrinkling of the hands and feet; mud or debris within the mouth and airways; white or bloody frothy fluid within the airways and at the mouth and nose; hyperinflated and heavy lungs that exude voluminous fluid from the cut surface; pulmonary edema and hemorrhage; water or debris in the stomach; dilation of particularly the right side of the heart; variable cerebral edema with red-brown discoloration of the cortical stripe in salt water drowning; clear or bloody fluid within the sphenoid sinus; and middle ear or mastoid air cell hemorrhage (1–3).

When a body is found on land, hemorrhage of the neck musculature without obvious injury of the external neck may be evidence of a concealed homicide (4). Interpretation of such neck hemorrhage when a body is recovered from the water is more controversial. It has been asserted that "scleral hemorrhages and hemorrhage in the anterior neck muscles which are often seen in cases of strangulation do not occur in drowning and should always raise the suspicion of foul play" (1, pp. 861–4). However, a retrospective review of 99 drowning deaths found neck hemorrhage in eight cases (8.1%; [5]). A prospective study of 39 drownings reported hemorrhages within the neck, trunk, and upper extremities in 20 cases (51.3%; [6]). The hemorrhages in the two previous studies were attributed to: violent neck movements, agonal convulsions, and muscle hypercontraction during the drowning process; or decomposition and hypostasis (5,6). Extensive intramuscular hemorrhages within the neck, shoulder girdle, and upper arms were documented in a drowning victim in an additional case report (7). Hemorrhage in the retropharyngeal soft tissue of the neck is a common postmortem artifact, which should not in isolation be interpreted as evidence of trauma (8).

Some workers assert that drowning-related periorbital and conjunctival petechial hemorrhages are seldom or uncommon (3,9). A retrospective review of 5000 autopsies in Miami found conjunctival petechiae in 7 of 171 drowning deaths (4.1%; [10]). A retrospective review of accidental pediatric drownings reported periorbital and conjunctival petechiae more commonly in 10 of 79 cases (12.7%; [11]). Another study found petechiae of the head in three of 19 drowning deaths (15.8%; [12]). Conjunctival petechiae may disappear in fresh water drowning because of hemolysis (13). Frank scleral hemorrhage has not been previously reported in association with drowning.

Petechiae are thought to be generated when elevated cephalic venous pressure causes rupture of relatively unsupported capillaries and venules within the eyes or eyelids (9). Although pressure on the neck may lead to petechiae by allowing arterial inflow of blood while blocking venous drainage, asphyxia and hypoxia per se do not cause them. Furthermore, a violent struggle, strenuous abdominal or thoracic contractions, coughing, gagging, and vomiting can lead to an elevated blood pressure, which is communicated from the head via the valveless veins of the neck and thus enhance the formation of petechiae (9). Acute asthmatic attacks can produce conjunctival petechiae by a similar mechanism, namely, increased intra-thoracic pressure in an attempt to overcome airway obstruction results in venous congestion and vasculature rupture within the eyes (14). Petechiae can also be produced during decomposition, particularly if the body is prone or in a head down position (10). "Tardieu spots" are petechial-like hemorrhages produced in areas of livor mortis because of the rupture of engorged blood vessels.

Several studies have concluded that conjunctival and facial skin petechiae can be generated by CPR (10,15–17). In contrast, a review of autopsies in Germany found that cause of death, particularly acute cardiac death, was the best predictor of the occurrence of petechiae; a relationship between petechiae and administration of CPR was not supported (12,18). In a cohort of pediatric accidental drowning victims, petechiae were not significantly associated with a history of resuscitation (11).

The present case documents scleral and neck hemorrhages in a drowning death. The circumstances and investigation essentially ruled out strangulation or homicide as the cause of death. The key card record of the door to the pool suggests a submersion interval of 5–10 min, a time frame supported by the complete recovery of the decedent's stepson within a day of the incident. Regardless of the exact submersion interval, decomposition and livor mortis

(hypostasis) are not a tenable explanation for the decedent's conjunctival hemorrhages. Likewise, CPR does not adequately explain the constellation of findings in this case, which included conjunctival and bilateral anterior–posterior neck hemorrhages. Consideration can be given to the possibility that inversion of the decedent's body in water (i.e., head down) contributed to the conjunctival hemorrhage as studies of inverted volunteers in air have shown increased intraocular pressure associated with eyelid petechiae and conjunctival hemorrhages (19,20). However, the results of these inversion studies cannot be simply applied to the case at hand where decedent was recovered from an aqueous environment. Also, the reported history was that the decedent was found laying face down on the bottom of the pool, not head down. Finally, inversion of the body would not explain the associated bilateral anterior–posterior neck hemorrhages.

We suggest the following mechanism to explain the constellation of findings reported in this case—elevated central venous pressure occurs in response to drowning-related coughing, gagging, vomiting, and forceful abdominal and thoracic contractions (21,22). The elevated central venous pressure causes acute right heart dilation as described in this case. The elevated central venous pressure is communicated through the neck via valveless veins to the cephalic region. Elevated intravascular pressure in the neck can result in marked congestion of the thyroid gland. Capillaries and venules would rupture in response to elevated intravascular pressure as a function of their relative vulnerability as determined by the support of surrounding connective tissue. The enhanced vulnerability of ocular and eyelid vessels to congestive rupture would explain the previous observation that fascial skin petechiae only occur in conjunction with conjunctival petechiae (9,23). With sufficient elevation of central venous pressure, continued bleeding into the conjunctivae leads to florid hemorrhage as seen in this case, not just petechiae. Likewise, rupture of vessels in the sphenoid sinus results in petechiae and hemorrhage at this site. The occurrence of drowning-related tympanomastoid hemorrhage (24,25) is because of the rupture of vulnerable capillaries and venules in this area. Finally, sufficiently elevated central venous pressure could be communicated to vessels within the anterior and posterior neck resulting in congestion and hemorrhage on the fascial surface of the muscles, as described in this report.

In conclusion, when a body is recovered from water, postmortem findings of scleral and fascial neck muscle hemorrhages in isolation should not be interpreted as evidence of homicidal pressure across the neck. These autopsy findings can be explained in an accidental drowning by communication of drowning-related elevated central venous pressure to the neck and head. We further suggest that hemorrhage throughout the substance of the neck musculature, not just confined to its fascial surface, requires further investigation into the possibility of traumatic injury to the neck (e.g., strangulation).

Acknowledgment

We thank David Fowler, MD, for his critical review of the manuscript.

References

1. Spitz DJ. Investigation of bodies in water. In: Spitz WU, Spitz DJ, editors. Spitz and Fisher's medicolegal investigation of death, 4th edn. Springfield, IL: Charles C. Thomas, 2006;846–81.
2. Piette MHA, De Letter EA. Drowning: still a difficult autopsy diagnosis. Forensic Sci Int 2006;163(1–2):1–9.
3. Saukko P, Knight B. Knight's forensic pathology, 3rd edn. London: Arnold, 2004.
4. Sadler DW. Concealed homicidal strangulation first discovered at necropsy. J Clin Pathol 1994;47:679–80.
5. Carter N, Ali F, Green MA. Problems in the interpretation of hemorrhage into neck musculature in cases of drowning. Am J Forensic Med Pathol 1998;19(3):223–5.
6. Puschel K, Schulz F, Darrmann I, Tsokos M. Macromorphology and histology of intramuscular hemorrhages in cases of drowning. Int J Legal Med 1999;112(2):101–6.
7. Sigrist T, Schulz F, Koops E. Confusing muscular hemorrhage in a drowned cadaver. A contribution to differentiation between vital and postmortem changes. Arch Kriminol 1994;193(3–4):90–6.
8. Prinsloo I, Gordon I. Post-mortem dissection artifacts of the neck; their differentiation from ante-mortem bruises. S Afr Med J 1951;25(21):358–61.
9. Ely SF, Hirsch CS. Asphyxial deaths and petechiae: a review. J Forensic Sci 2000;45(6):1274–7.
10. Rao VJ, Wetli CV. The forensic significance of conjunctival petechiae. Am J Forensic Med Pathol 1988;9(1):32–4.
11. Somers GR, Chiasson DA, Taylor GP. Presence of periorbital and conjunctival petechial hemorrhages in accidental pediatric drowning. Forensic Sci Int 2008;175:198–201.
12. Maxeiner H. Congestion bleeding of the face and cardiopulmonary resuscitation—an attempt to evaluate their relationship. Forensic Sci Int 2001;117(3):191–8.
13. Betz P, Penning R, Keil W. The detection of petechial haemorrhages of the conjunctiva in dependency on the postmortem interval. Forensic Sci Int 1994;64(1):61–7.
14. Rodriguez-Roisin R, Torres A, Agusti AGN, Ussetti P, Agusti-Vidal A. Subconjuctival haemorrhage: a feature of severe asthma. Postgrad Med J 1985;61:579–81.
15. Hood I, Ryan D, Spitz WU. Resuscitation and petechiae. Am J Forensic Med Pathol 1988;9(1):35–7.
16. Raven KP, Reay DT, Harruff RC. Artifactual injuries of the larynx produced by resuscitative intubation. Am J Forensic Med Pathol 1999; 20(1):31–6.
17. Hashimoto Y, Moriya F, Furumiya J. Forensic aspects of complications resulting from cardiopulmonary resuscitation. Leg Med 2007; 9(2):94–9.
18. Maxeiner H, Winklhofer A. Eyelid petechiae and conjunctival hemorrhage after cardiopulmonary resuscitation. Arch Kriminol 1999; 204(1–2):42–51.
19. Friberg TR, Weinreb RN. Ocular manifestations of gravity inversion. JAMA 1985;253(12):1755–7.
20. Friberg TR, Sanborn G, Weinreb RN. Intraocular and episcleral venous pressure increase during inverted posture. Am J Opthalmol 1987; 103(4):523–6.
21. Pearn J. Pathophysiology of drowning. Med J Aust 1985;142(11):586–8.
22. Hasibeder WR. Drowning. Curr Opin Anaesthesiol 2003;16:139–46.
23. Luke JL, Reay DT, Eisele JW, Bonnell HJ. Correlation of circumstances with pathological findings in asphyxial deaths by hanging: a prospective study of 61 cases from Seattle, WA. J Forensic Sci 1985; 30(4):1140–7.
24. Liu C, Babin RW. A histological comparision of the temporal bone in strangulation and drowning. J Otolaryngol 1984;13(1):44–6.
25. Robbins RD, Sekhar SK, Siverls V. Temporal bone histopathologic findings in drowning victims. Arch Otolaryngol Head Neck Surg 1988; 114(9):1020–3.

Additional information and reprint requests:
Russell T. Alexander, M.D.
Office of the Chief Medical Examiner for the State of Maryland
900 W. Baltimore Street
Baltimore, MD 21201
E-mail: alexanderr@ocmemd.org