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EDITORIAL

Immersion deaths and drowning: issues arising in the investigation of bodies recovered from water

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Drowning has been described in various ways however it generally refers to death within 24 h of a submersion incident, with "near drowning" as survival for at least 24 h after the incident [1]. According to the World Health Organization (WHO) "drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid" [2]. The diagnosis is one of exclusion that requires a detailed history of a victim being found in or near water with no potentially lethal diseases/injuries present, unless these have initiated the drowning episode. Unfortunately, although the diagnosis of drowning may seem relatively straightforward, this may be far from the case. For example in unwitnessed cases questions may never be resolved concerning the exact circumstances and manner of death. It is also likely that official statistics on drowning deaths are underestimates [3].

Problems that arise start with the scene. Death scenes in drowning deaths are often uncontrolled, involving long sections of rivers, or areas of sea or lakeshore. This is particularly so in cases of multiple drowning deaths in underwater disaster victim identification/management exercises [4]. Failure to locate a body quickly may result in extensive changes due to both decomposition and to post mortem animal predation. Animals as varied as sea lice and sharks may significantly alter the features of a body, and may modify or create wounds [5]. A reliable history may not be available if the immersion incident was not observed, and distinguishing injuries that may have been sustained prior to death from those that have occurred afterwards may not be possible. The post mortem movement of a body with a fast river current or with tides or waves may also cause significant damage that may interfere with identification. It is however, sometimes surprising that even small amounts of tissue/body parts that may be recovered, often after considerable time has elapsed, can still lead to a positive identification [6].

In addition, merely because a body has been found in water does not mean that drowning has occurred. Conversely, a body may not necessarily be found immersed in water if, for example, it has been left behind by a receding tide. The possibilities when a body is retrieved from water include drowning, which may be accidental, suicidal or homicidal [7], or drowning precipitated by underlying natural disease. For example, the risk of drowning is 15–19 times greater in people with epilepsy [8, 9]. Alternatively death may not involve drowning at all, but may be due to an unrelated injury, whether accidental or inflicted, or to natural disease. It is well recognized that certain cardiac channelopathies, such as LQT1, may result in lethal arrhythmias while swimming [10]. For this reason the autopsy examination in cases of suspected drowning must be meticulous in looking for a wide range of possible underlying organic conditions.

The mechanism of death in drowning is complicated and involves more than just asphyxia from filling of the airways with fluid, but also hydrostatic and osmotic effects [11], although the clinical significance of the latter has been debated [12]. While the existence of so-called "dry drowning" is also argued, it is considered that certain victims may suffer airway obstruction from laryngeal spasm [13]. It has been suggested that the time from immersion to cardiac

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arrest may be only seconds to minutes, although this may be longer in cold environments [14].

The autopsy findings in drowning cases are often characteristic but are not diagnostic, and so must be viewed in the context of each case. Externally the first observations may be sand, seaweed, or other vegetation covering the body, wrinkling of the skin of the hands and feet (so-called "washer-woman" changes), and injuries to the dorsa of the feet and to the knees. However, these findings merely indicate that a body has been submerged, and has then been traumatized by dragging across a river or sea bottom. The existence of cadaveric spasm [15] in drowning victims, the "straw" that a drowning man allegedly clutches, has also been debated [16]. Other findings at autopsy of marked pulmonary edema with so-called "emphysema aquosum" are again not specific for drowning, as significant edema may occur in a range of other conditions/circumstances including congestive heart failure, narcotic drug overdose, or following prolonged resuscitation [10]. Again the presence of small straw-colored pleural effusions and watery fluid within the stomach is nonspecific. In the current issue of *Forensic Science Medicine and Pathology* the potential significance of differential staining of the aortic and pulmonary trunks is discussed [17]. This is something which has been well recognized in the German, but not the more recent English, literature as a finding in fresh water drowning that is caused by intravascular hemolysis [18–21]. On occasion new observations, even from veterinary practice, are made which may help to clarify particular issues, such as impacted endobronchial sand casts when drowning has occurred in areas of sea turbulence [22].

Laboratory testing has been generally disappointing in the evaluation of possible drowning deaths. For example, searching for microscopic silicaceous algae (diatoms) found in water has not been of much use in the majority of cases. Electrolyte studies comparing chloride levels in the left and right ventricles first proposed by Gettler [23] has also not proven reliable [24]. It is noted, however, that post mortem left ventricular and vitreous humor sodium levels in saltwater drowning have been shown to be significantly higher than in freshwater drowning [25, 26] most likely due to differential fluid distribution.

While the pathological findings may support the fact that a body has been immersed in water, this may be self-evident from the history, and may not necessarily clarify whether drowning has occurred or not. The usefulness of the pathology findings lies in the fact that a collection of typical findings provides strong supportive evidence for drowning, so the "diagnosis", as in many conditions that are encountered in forensic pathology, comes down to the balance of probabilities, and the exclusion of other natural or unnatural possibilities. The manner of death is also something that relies heavily on an integration of circumstantial evidence, the history of the decedent, and the autopsy findings. Thus, although drowning may initially appear an uncomplicated process, significant unresolved and unresolvable issues relating to the cause, mechanism and manner of death may still be encountered in the evaluation of individual cases.

References

1. Zuckerman GB, Conway EE. Drowning and near drowning: a pediatric epidemic. Pediatr Ann. 2000;29:360–6.
2. van Beeck EF, Branche CM, Szpilman D, Modell JH, Bierens JJ. A new definition of drowning; towards documentation and prevention of a global public health problem. Bull World Health Organ. 2005;83:853–6.
3. Lu TH, Lunetta P, Walker S. Quality of cause-of-death reporting using ICD-10 drowning codes; a descriptive study of 69 countries. BMC Med Res Methodol. 2010;10:30.
4. Winskog C. Underwater disaster victim identification: the process and the problems. Forensic Sci Med Pathol. 2012;8:174–8.
5. Byard RW, James RA, Gilbert JD. Diagnostic problems associated with cadaveric trauma from animal activity. Am J Forensic Med Pathol. 2002;23:238–44.
6. Byard RW, Simpson E, Both K. The identification of submerged skeletonised remains. Am J Forensic Med Pathol. 2008;29:69–71.
7. Byard RW, Houldsworth G, James RA, Gilbert JD. Characteristic features of suicidal drownings. A 20 year study. Am J Forensic Med Pathol. 2001;22:134–8.
8. Bell GS, Gaitatzis A, Bell CL, Johnson AL, Sander JW. Drowning in people with epilepsy: how great is the risk? Neurology. 2008;71:578–82.
9. Smith NM, Byard RW, Bourne AJ. Death during immersion in water in childhood. Am J Forensic Med Pathol. 1991;12:219–21.
10. Byard RW. Sudden death in the young. 3rd ed. Cambridge: Cambridge University Press; 2010.
11. Lawler W. Bodies recovered from water: a personal approach and consideration of difficulties. J Clin Pathol. 1992;45:654–9.
12. Orlowski JP, Abulleil MM, Phillips JM. The hemodynamic and cardiovascular effects of near-drowning in hypotonic, isotonic, or hypertonic solutions. Ann Emerg Med. 1989;18:1044–9.
13. Modell JH. Pathophysiology of drowning and near drowning. Springfield: Charles C Thomas; 1971.
14. Szpilman D, Bierens JJLM, Handley AJ, Orlowski JP. Drowning. N Engl J Med. 2012;366:2102–10.
15. Prahlow J, Byard RW. An Atlas of forensic pathology. New York: Springer; 2012.
16. Bedford PJ, Tsokos M. The occurrence of cadaveric spasm is a myth. Forensic Sci Med Pathol. 2013;9:244–8.
17. Byard RW. Aortic intimal staining in drowning. Forensic Sci Med Pathol. 2014. doi:10.1007/s12024-014-9563-6.
18. Dettling J, Schönberg S, Schwarz F. Lehrbuch der Gerichtlichen Medizin. Basel: Karger; 1951. p. 300.
19. Ponsold AE. In: Ponsold A, editor. Lehrbuch der Gerichtlichen Medizin einschliesslich der ärztlichen Rechtskunde und der Versicherungsmedizin. Stuttgart: Thieme; 1957. p. 375–87.
20. Tsokos M, Cains G, Byard RW. Hemolytic staining of the intima of the aortic root in freshwater drowning – a retrospective study. Am J Forensic Med Pathol. 2008;29:128–30.
21. Byard RW, Cains G, Tsokos M. Haemolytic staining of the intima of the aortic root—a useful pathological marker of fresh water drowning? J Clin Forensic Med. 2006;12:125–8.

22. Byard RW, Machado A, McLelland D. Endobronchial sand casts – an unusual marker of saltwater inhalation in a juvenile pygmy sperm whale (*Kogia breviceps*). Forensic Sci Med Pathol. 2011;7:222–4.
23. Gettler AO. A method for the determination of death by drowning. J Am Med Assoc. 1921;77:1650–2.
24. DiMaio DJ, DiMaio VJM. Forensic pathology. 2nd ed. New York: Elsevier; 2001.
25. Byard RW, Summersides G. Vitreous humor sodium levels in immersion deaths. J Forensic Sci. 2011;56:643–4.
26. Byard RW, Cains G, Simpson E, Eitzen D, Tsokos M. Drowning, haemodilution, haemolysis and staining of the aortic root—preliminary observations. J Clin Forensic Med. 2006;13:121–4.