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A fatal drowning filmed in a private pool: Analysis of the sequences of submersion

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ABSTRACT

Investigating a body found in water, without eyewitnesses, to determine the cause and manner of death is often difficult. Video recorded by a surveillance camera can document events and provide useful data for case assessment. The authors report the case of a 26-year-old man found dead in a swimming pool. The images taken by the surveillance camera are useful for reconstructing what happened: to confirm the autopsy by attributing the cause of death by drowning, without the interference of extrinsic factors. The sequence of events related to the submergence of the body, as seen from the video surveillance recording, does not seem to differ much from that described in the experiments reported in the literature even if it presents some discrepancies on the times of death, having been able to precisely control the times of death by acquiring the video surveillance. Reporting this drowning in a swimming pool has yet to be considered an isolated important case study for the study of the drowning process in humans.

Introduction

Investigating a body found in water means determining its cause (drowning, natural disease, etc.) and the manner of death (murder, suicide or accident) is often a challenge for the forensic pathologist [1,2].

In such cases, circumstantial evidence is very important as witness statements, if they were present, but only if they can be consistent. The presence of video surveillance images can certainly help to accurately define the time of death even if the images cannot always exclude with certainty the mode of suicidal or accidental death, although suicides by drowning have decreased in most countries in the last years [3].

Lunetta et al. examined 1590 consecutive cases of bodies found in water (accident, suicide, indeterminate, homicide, natural), during the period 1976–1998 in which eyewitnesses were present in 25.3% of the total cases and only in 12 cases of swimming pool events [4].

In fact, in a drowning accident in the swimming pool there is not always a witness, or he can describe the case as it occurred, helping investigations to understand the event. The absence of a eyewitnesses is more frequent in private pools where a corpse is discovered retrospectively, often after a long time and complicating investigations that must also take into account, for example, any malfunctions of the pool water drainage system [5].

In these cases, no one can say with certainty that the drowning was accidental or suicidal excluding the liability of third parties. Indeed sometimes death has nothing to do with a puddle, but is where the body is dumped, and examiners have not been able to determine whether or not he was conscious when he drowned. In these cases, the presence of video recordings helps to resolve these investigative doubts but main doubts remain about the duration of entire drowning process, from immersion or immersion to cardiac arrest and subsequent brain death is controversial and difficult to resolve in relation a the answer to the question on the possibility rescue operations [6].

The location of the victim at the time of the discovery can have considerable importance for the evaluation of the case and, as happens in other areas such as for training in water rescue, a historical re-enactment, using a mannequin, may be necessary to clarify the event. In this context, a video recorded by a surveillance camera (security camera) can also document the trend of events and provide useful data for the evaluation of the case [7].

Therefore, if the time of death was recorded by some cameras, the video can be used both as proof of the time of death and to scientifically confirm what is known in the literature about the time of drowning.

Case report

The body of a 26-year-old man was found submerged in a private freshwater pool on a summer day.

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Fig. 1. External examination of body with cone of foam at the mouth and nostrils.

The external examination, performed 3 h after death and 2 h after the discovery of the body, showed the cone of foam at the mouth and nostrils (Fig. 1).

That foam was stained with blood, and reappeared after drying it, as a result of body movements. There were no recent lesions on the surface of the skin; abundant bilateral subungual cyanosis was evident.

During the autopsy, during internal investigation, the airways also contain foamy fluid. The right lung weighs 520 g, the left 500 g. Inspection, the lungs are large and completely occupy their pleural cavities, and large amount of edematous fluid flowed from the cut surfaces. There was about 700 cc of water in the stomach. Normal heart and coronary vessels.

Film analysis

The recorded video includes the entire pool area where the victim committed the crime. Image quality is poor as this usually a color surveillance camera (330 lines only) although sufficient to capture all stages of drowning. However the video includes, a timepiece with the indication of hours, minutes, seconds (Fig. 2).

The man, who at that moment was left alone, undresses and enters the water from the edge of the pool, after having taken a running start and jumped on a trampoline placed about one meter above the water level (time of entry in water: 12:47:53). The area of the pool in which the man dives is the one with the maximum depth (about five meters) and corresponds precisely to the side of the diving board. Now, as happens when an inexperienced swimmer falls into the water, initially the man sinks to reappear thanks to the thrust from the bottom upwards equal to the weight of the displaced fluid displaced volume.

Subsequently the intense shaking movements of the limbs can be interpreted as desperate attempts to avoid being submerged or to re-emerge (time of intense shaking: 12:48:20–12:48:56). If then alternates the first phases of sinking and emergence of the head, even several times in a few seconds (time of sinking and emergency of the head: 12:48:57–12:49:49). Subsequently, the movements become slower and therefore the body is completely submerged (full immersion time: 12:49:50). Finally you can still see the rhythmic movements of the limbs, in the meantime the body collapses and shortly after stops moving (movement end time: 12:49:51–12:49:59).

Discussion

The death in the swimming pool, like that in the bathtub, is a particular circumstance in which the forensic investigation must proceed first to exclude other harmful events and secondary to consider the possibility of an atypical drowning occurred to an unconscious person, for natural causes of illness (such as seizures) or violent actions and toxic intoxication. Indeed, water death is a challenging problem in forensic pathology since all circumstances of water death are conceivable from natural death to murder [8,9].

The images taken by the surveillance camera are very useful for the reconstruction of the incident in a case where, as often happens in a private swimming pool, there were no witnesses. In this case, the video made it possible to confirm the autopsy by attributing the cause of death by drowning, without the interference of other extrinsic factors that show that the person able to move easily and quickly, undress and voluntarily dive into the pool.

In accordance with the given circumstance, the autopsy confirmed the classic findings of drowning revealing on external examination, the cone of foam at the mouth and nostrils [10]. On internal investigation, the airways also contained foamy fluid. The lungs were large and completely occupied their pleural cavities and, on cut section, large quantities of edematous fluid flowed from the cut surfaces. These aspects, among other things, allows to exclude those fatal effects from laryngospasm or by reflex inhibition to stimulation of the nasopharyngeal-laryngeal mucosa.

Fig. 2. Sequences of the drowning.

Based on these effects, before watching the video it was believed that death could be determined immediately after the initial phase of apnea without aspiration of water, known as dry drowning [11]. However the most recent studies believe that a drowning cannot occur without the aspiration of a certain amount of liquid. Indeed, drowning probably never occurs without aspiration to some extent [12–14].

This is a well-known hypothesis in forensic pathology, in fact as early as in 1963, Fuller demonstrated that hypervolemia was not common in freshwater drowning and human drowning victims seem to suck in less water than those obtained in total immersion from 51 studies about animals [15].

According to the consensus definition of the 2002 World Congress on Drowning: “Drowning is the process of experiencing respiratory damage due to immersion/immersion in a liquid” [16]. The “drowning process” begins when the person's airways sink below the surface of the liquid (immersion) and then the person voluntarily stops breathing [6,17].

The brain is the most vulnerable organ to asphyxiation, and brain damage occurs before heart problems while diving [18]. Death is secondary to the development of brain hypoxia which leads to irreversible brain damage. Indeed, several phases have been described during the drowning process, first a breath holding phase, followed by involuntary inhalation, gasping for air and loss of consciousness.

The duration of phases depends on various factors, such as age, previous pathologies, the victim’s tolerance to apnea, the temperature and quantity of water sucked in and the state of health of the victim before drowning. Hence, it has been rightly stated that there are no two cases of drowning identical. Pearn (1985) reports that somatic death occurs within 1–60 min of immersion (median 3–10 min) depending on age, water temperature and degree of tissue hypoxia [19].

Hypothermia associated with drowning such as in drowning in ice water, provides a protective mechanism and the process can last an hour [19]. Szpilman et al. believe that the entire drowning process, from immersion or immersion to cardiac arrest, usually occurs within seconds or minutes [6]. These data are mostly derived from the study of the possibility of recovery of people rescued in different conditions and in variable times after immersion and treated resuscitation, cases of drowning near a defined time as there are no reviews in the literature on numerous cases drowning recorded by video cameras as in the present case study.

Instead serious doubts have been posed on the possibility of transferring human drowning the sequence of phases studied extensively on animal models. In these the duration of the drowning process is undoubtedly influenced by the particular conditions of the experiment. In this case the quality of the images, taken by a surveillance camera is rather poor. However, an external camera may not allow adequate assessment of agonal sequences as reported in the filmed suicidal hanging [20]. In fact, the "drowning process" is determined for the most part when the airways are below the level of the drowning liquid and therefore the body is completely submerged and can only be adequately filmed with advanced surveillance systems and specific underwater cameras, however, still not very widespread.

However it must be emphasized, that the sequence of events related to the submergence of the body in this case study, as seen from the video recording does not seem to differ much from that described in the classic experiments of Brouardel and Loye in 1889, indeed if there are some interesting differences with important food for thought [21].

The authors found that the first phase of drowning was represented by the rapid submersion of the victim followed soon after by the inhalation of a little amount of drowning medium, agitation and respiratory distress. Thanks to the video footage analyzed, in our case this first phase lasted 27 s

The same authors describe a second phase of resistance, lasting about one minute, in which the victim is shaken and violently fights (in our case this first phase lasted 54 s) and then, with a third phase of stopping the general movements and the state of agitation in which the victim goes to the bottom (in our case this first phase lasted 10 s).

In this phase of life of about one minute in animal model rather intense movements of inhalation and exhalation occur with flooding of the fluid in the airways. The sequence of the drowning phases reported in the nineteenth century by Brouardel and Loye has been confirmed by numerous experiments on animal models in the last century [21,22].

The event archive in this case seems to confirm the occurrence of an initial phase in which the desperate attempts and the initial agitation to not be submerged or to emerge can be considered equivalent to a phase of resistance followed by a phase in which the victim bears to the lower part. The shaking movements of the limbs, associated with a state of panic, favor the inhalation of the liquid medium and the alternation of the sinking and floating phases of the victim, triggering the sequence that will be rapidly asphyxiated to irreversible cerebral anoxia and therefore to exitus.

It should be noted that the time recorded by the camera in which the detectable phases are held, from entering the water to sinking of the body is very close (about 2 min) to the duration of the first two phases described in animal models by Brouardel and Loye. The aspects described and the set of video footage, however, do not allow to resolve the doubt about the manner of death because even a hypothesis of suicide and accidental can be considered plausible [23]. In fact, the movements of intense agitation visible in the initial phase of "resistance" can be considered instinctive in humans as well as in animal models and therefore present in eventuality both accidental (for example, in a person inexperienced in swimming sick) and suicidal (survival instinct). Therefore, what is important to an investigative forensic pathologist is that the inclusion of witnessed cases among the “certain” drownings is somewhat arbitrary, because the reliability of witnesses can be questionable.

It is also important to always remember that, although in the present case study, video surveillance recording are sufficient evidence to determine the manner and cause of death, using all reasonable methods and techniques to support a reliable diagnosis of the cause fundamental importance. of death every time. Drowning is still a difficult autopsy diagnosis and is an exclusion diagnosis that requires information from the recovery scene and witness reports. Even when video surveillance recording are available, the cause of death should be better supported by the presence of any aquatic microorganism (diatoms or bacteria) derived from the drowning medium in the tissues of the drowning victim in order to demonstrate the hematogenous spread of these particles from the lung require a beating heart. Although controversial, the diatom test is still considered the “golden standard” for the diagnosis of drowning even in the forensic veterinary field [24,25]. Bacteria are smaller than diatoms and microbiological testing has also been proposed as new reliable indicator of seawater and freshwater drowning [26,27].

The importance of an autopsy diagnosis, in fact, is decisive in many cases and often must also be associated with laboratory investigations.

According to relevant literature, there are no pathognomonic findings at autopsy indicating drowning as cause of death including foam plume at the mouth. Most of the external and internal signs are nonspecific, and in combination are simply indicative of a violent process of asphyxiation caused by drowning. Many biological and tatochemical of drowning have been proposed [24]. They are mainly based on the physical and biochemical changes that occur in arterial blood compared to venous blood due to the marked hemodilution caused by drowning in fresh water or, by blood concentration with electrolyte shifts in saltwater drowning [28]. Unfortunately, many different plasma chemicals analyzes still do not provide any reliable evidence of drowning [29–31], but, for example, analysis of strontium absorbed into the bloodstream can provide useful information for establishing the length of the agonal period of drowning victims [32]. Significant hyponatremia secondary to hemodilution can also occur in left ventricle in case of freshwater drowning [33].

Reporting this drowning in a swimming pool has yet to be

considered an isolated case study and it would not be correct to consider these data as extensible to other cases. However, as documented, it can provide, especially compared to similar films shot in other cases, a contribution to the study of the drowning process of man.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] L.G. de la Grandmaison, F. Paraire, Place of pathology in the forensic diagnosis of drowning, Ann. Pathol. 23 (5) (2003) 400–407.
[2] M.H. Piette, E.A. De Letter, Drowning: still a difficult autopsy diagnosis, Forensic Sci. Int. 163 (1–2) (2006) 1–9, https://doi.org/10.1016/j.forsciint.2004.10.027
[3] C. Haw, K. Hawton, Suicide and self-harm by drowning: a review of the literature, Arch. Suicide Res. 20 (2) (2016) 95–112, https://doi.org/10.1080/13811118.2015.1025120
[4] P. Lunetta, A. Penttila, A. Sajantila, Circumstances and macropathologic findings in 1590 consecutive cases of bodies found in water, Am. J. Forensic Med Pathol. 23 (4) (2002) 371–376, https://doi.org/10.1097/00000433-200212000-00015
[5] M. Atilgan, D. Bulgur-Kirbas, R. Akman, C. Deveci, Fatal drowning caused by a swimming pool drainage system, Am. J. Forensic Med Pathol. (December) (2020), https://doi.org/10.1097/PAF.0000000000000643 (Publish Ahead of Print).
[6] D. Szpilman, J. Bierens, A.J. Handley, J.P. Orlowski, Drowning, New Engl. J. Med. 366 (2012) 2102–2110, https://doi.org/10.1056/NEJMra1013317
[7] A. Claesson, L. Svensson, P. Nordberg, M. Ringh, M. Rosenqvist, T. Djarv, J. Samuelsson, O. Hernborg, P. Dahlbom, A. Jansson, J. Hollenberg, Drones may be used to save lives in out of hospital cardiac arrest due to drowning, Resuscitation 114 (May) (2017) 152–156, https://doi.org/10.1016/j.resuscitation.2017.01.003
[8] S. Schneppe, M. Dokter, B. Bockholdt, Macromorphological findings in cases of death in water: a critical view on “drowning signs”, Int J. Leg. Med. 135 (1) (2021) 281–291, https://doi.org/10.1007/s00414-020-02469-9
[9] J.J. Bierens, P. Lunetta, M. Tipton, D.S. Warner, Physiology of drowning: a review, Physiology 31 (2) (2016) 147–166, https://doi.org/10.1152/physiol.00002.2015
[10] B. Knight, Forensic Pathology, Arnold, London, 1991.
[11] D. Szpilman, J. Sempsrott, J. Webber, S.C. Hawkins, R. Barcala-Furelos, A. Schmidt, A.C. Queiroga, “Dry drowning” and other myths, Clevel. Clin. J. Med. 85 (7) (2018) 529–535, https://doi.org/10.3949/ccjm.85a.17070
[12] J.H. Modell, M. Bellefleur, J.H. Davis, Drowning without aspiration: is this an appropriate diagnosis? J. Forensic Sci. 44 (6) (1999) 1119–1123.
[13] P. Lunetta, J.H. Modell, A. Sajantila, What is the incidence and significance of “dry-lungs” in bodies found in water? Am. J. Forensic Med. Pathol. 25 (4) (2004) 291–301, https://doi.org/10.1097/01.paf.0000146240.92905.7e
[14] F. Salomez, J.L. Vincent, Drowning: a review of epidemiology, pathophysiology, treatment and prevention, Resuscitation 63 (3) (2004) 261–268, https://doi.org/10.1016/j.resuscitation.2004.06.007
[15] R. Fuller, The 1962 Wellcome prize essay, Mil. Med. 128 (1963) 22–36.
[16] E.F. Van Beeck, C.M. Branche, D. Szpilman, J.H. Model, J.J.L.M. Bierens, A new definition of drowning: towards documentation and prevention of a global public health problem, Bull. World Health Organ. 83 (11) (2005) 853–856 Epub 2005 Nov 10.
[17] A.H. Idris, R.A. Berg, J. Bierens, L. Bossaert, C.M. Branche, A. Gabrielli, S.A. Graves, A.J. Handley, R. Hoelle, P.T. Morley, L. Papa, P.E. Pepe, L. Quan, D. Szpilman, J.G. Wigginton, J.H. Modell, D. Atkins, M. Gay, W. Kloeck, S. Timerman, Recommended guidelines for uniform reporting of data from drowning: the “Utstein Style”, Circulation 108 (2003) 2565–2574, https://doi.org/10.1161/01.CIR.0000099581.70012.68
[18] J.J. Bierens, J. Knape, H.P. Gelissen, Drowning, Curr. Opin. Crit. Care 8 (6) (2002) 578–586, https://doi.org/10.1097/00075198-200212000-00016
[19] J. Pearn, The management of near drowning, Br. Med J. Clin. Res Ed. 291 (6507) (1985) 1447–1452, https://doi.org/10.1136/bmj.291.6507.1447
[20] A. Sauvageau, R. LaHarpe, D. King, G. Dowling, S. Andrews, S. Kelly, C. Ambrosi, J.P. Guay, V.J. Geberth, Agonal sequences in 14 filmed hangings with comments on the role of the type of suspension, ischemic habituation and ethanol intoxication on the timing of agonal responses, Am. J. Forensic Med. Pathol. 32 (2) (2011) 104–107, https://doi.org/10.1097/PAF.0b013e3181efba3a
[21] P. Brouardel, P. Loye, La respiration pendant la submersion brusque, Arch. Physiol. (1889).
[22] A. Dell’Erba, M. Santini, Physiopathology of drowning, Minerva Med. 86 (1) (1966) 32–64.
[23] D. Samuel, L. Sher, Suicidal behavior in Indian adolescents, Int J. Adolesc. Med Health 25 (3) (2013) 207–212, https://doi.org/10.1515/ijamh-2013-0054
[24] M.H.A. Piette, E.A. De Letter, Drowning: still a difficult autopsy diagnosis, Forensic Sci. Int. 163 (1–2) (2006) 1–9, https://doi.org/10.1016/j.forsciint.2004.10.027
[25] N. Fucci, C.P. Campobasso, L. Mastrogiuseppe, C. Puccinelli, S. Marcheggiani, L. Mancini, L. Marino, V.L. Pascali, Diatoms in drowning cases in forensic veterinary context: a preliminary study, Int J. Leg. Med. 31 (2017) 1573–1580, https://doi.org/10.1007/s00414-017-1565-y
[26] E. Kakizaki, K. Takahama, Y. Seo, S. Kozawa, M. Sakai, N. Yukawa, Marine bacteria comprise a possible indicator of drowning in seawater, Forensic Sci. Int 176 (2008) 236–247, https://doi.org/10.1016/j.forsciint.2007.09.018
[27] A. Lucci, C.P. Campobasso, A. Cirnelli, G. Lorenzini, A promising microbiological test for the diagnosis of drowning, Forensic Sci. Int 182 (2008) 20–26, https://doi.org/10.1016/j.forsciint.2008.09.004
[28] R. Jeanmonod, C.H. Staub, B. Mermillod, The reliability of cardiac haemodilution as a diagnostic test of drowning, Forensic Sci. Int 52 (1992) 171–180.
[29] G.L. de la Grandmaison, M. Leterreux, K. Lasseuguette, J.C. Alvarez, P. Mazancourt, M. Durigon, Study of the diagnostic value of iron in fresh water drowning, Forensic Sci. Int. 157 (2–3) (2006) 117–120, https://doi.org/10.1016/j.forsciint.2005.03.016 Epub 2005 Nov 8.
[30] J.E. Azparren, G. Vallejo, E. Reyes, A. Herranz, M. Sancho, Study of the diagnostic value of strontium, chloride, haemoglobin, and diatoms in immersion cases, Forensic Sci. Int. 91 (2) (1998) 123–132, https://doi.org/10.1016/s0379-0738(97)00186-2
[31] J.E. Azparren, A. Fernandez-Rodriguez, G. Vallejo, Diagnosing death by drowning in freshwater using blood strontium as an indicator, Forensic Sci. Int. 137 (1) (2003) 55–59, https://doi.org/10.1016/s0379-0738(03)00284-6
[32] J.E. Azparren, A. Ortega, H. Bueno, M. Andreu, Blood strontium concentration related to the length of the agonal period in seawater drowning cases, Forensic Sci. Int. 108 (1) (2000) 51–60, https://doi.org/10.1016/s0379-0738(99)00200-5
[33] R.W. Byard, G. Cains, E. Simpson, D. Eitzen, M. Tsokos, Drowning, haemodilution, haemolysis and staining of the intima of the aortic root preliminary observations, J. Clin. Forensic Med. 13 (3) (2006) 121–124, https://doi.org/10.1016/j.jcfm.2006.01.003