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Spectrum of Injuries Following Fatal Falls into Wells: Forensic Approach and Review of Literature

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Abstract

Falls into wells are a traumatic event that represents a major public health problem worldwide. These falls are often fatal in contrast to some falls from heights, given the depth of the well that has to be deep enough to reach the water aquifer. Despite the severity of the consequent injuries, falls into wells have not been documented enough in the medical literature. The purpose of this work was to study the characteristics of falls into wells referring to the literature to serve as a basis for proposing appropriate preventive measures to prevent such falls. The majority of the collected cases comprised suicide cases that died as a result of drowning or severe polytrauma. The pattern that emerged was similar to falls from heights with a predominance of head and skull fractures. Fractures of ribs and spine vertebrae were common, unlike long bone fractures. Several factors were involved in the pattern of damages such as body weight, speed, nature of the impacted surface, the orientation of the body at the time of impact, and the body part that hit the ground first.

Keywords: Falls wells; Injuries; Forensic medicine; Autopsy

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Introduction

AA fall is defined as an event that results in a person finding itself on the ground or any other surface, at a lower level than originally. The fall can occur from elevated heights (roofs, elevators, stepladders, steps, etc.) or at the edge of an opening in the ground (trenches, pits, wells, etc.). Although fall-related injuries are mostly not fatal, approximately 37.3 million falls occurring each year are severe enough to require medical attention. In fact, such falls are responsible for over 17 million disability-adjusted life years (DALYs) lost [1] (i.e., the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability) and account for 25%-34% of emergency admissions [2].

Falls from heights have been well studied in many scientific papers [3–8] that have investigated the pattern of fall injuries and their correlation with the height of the fall. However, falls into wells have less been documented despite their equal occurrence. Because of the depth of wells, corpses are usually not easy to see and therefore, they may remain there for a long time, resulting in disintegration and putrefaction. Hence, it may be difficult to found the body, to determine its identity, the cause, and the time of death.

A well is an excavation created in the ground by digging or drilling to access liquid resources. The oldest and most common kind of well is water well to access groundwater. The well's depth is variable, usually surrounded by a wall of variable height, and stabilized by cemented stone pieces or bricks to create an impervious well wall. There are several circumstances that may lead to the presence of corpses in wells. In fact, as falls from heights, falls into wells can be accidental or intentional (suicide attempt/homicide). The purpose of this work is to study the characteristics of falls into wells referring to the literature to serve as a basis for proposing appropriate preventive measures to prevent such falls.

Literature Review

A A systematic literature search of articles published until April 2021 was performed using the PubMed database, ScienceDirect Scopus, Google scholar, EM-consulte, and Springer. Search keywords were *("falls into wells" OR "falls into pits" AND ("death" OR "fatal") AND ("injuries" OR "damages")+. An analytical evaluation of the studies collected was performed, and references from relevant articles were also reviewed for potential cases. Only cases of death in consequence of falls into wells were included.

Four articles [9–12] were identified, mainly conducted by forensic pathologists, for a total of 211 cases, as reported in **Table 1**. In our forensic practice, whenever there are signs or indications of violent death or suspicious circumstances surrounding the death, a medicolegal obstacle to burial must be marked on the death certificate in order to initiate a judicial investigation and a medicolegal autopsy to clarify the circumstances of death. Falls into wells are a type of violent death that requires an autopsy to eliminate a third-party intervention.

Sex, age, cause of death, manner of death, and characteristics of the wells in which the bodies were found are summarized in **Table 1**. In our review of 211 cases, the age reported ranged from 0 to 88 years old, with a male predominance in three-quarters of cases. For cases where the place of the body discovery has been indicated, the deceased were found in wells that were either around their workplace or their home. The depth of the well was quite significant in the majority of cases for a maximum depth of 70 meters and was unprotected (i.e., without a fence, a lid with a lock or curbstone) most of the time. In 20% of the cases, the bodies were recovered after a period ranging from nine days to two years, in an advanced state of decomposition. The cause of death could not be determined for some decomposed bodies due to the deterioration of some tissues, resulting in difficulties performing further post-mortem investigations. In a homicide case, the decedent was recovered from the well 1.5 months after the homicide following a confession by the defendant of the crime. When the causes of death were examined, it was observed that there was a significant difference for the accidental and suicidal cases, depending on the presence of water in the wells where the corpses were found. As a matter of fact, drowning was the common cause of death in suicide cases which sustained fewer injuries aside from skin abrasions not related to the cause of death, while severe polytrauma was the most observed cause of death in accidental cases occurring more commonly in empty wells. The trauma injuries in these cases were located in decreasing order in the skull (intracranial hemorrhage, contusion of the cerebrum, skull fractures…) followed by chest injuries (flail chest, hemopneumothorax, rib fractures…) and spine injuries. The spinal fractures were represented in descending order by thoracic spine fractures, cervical spine, and lumbar spine. The spectrum of bone damages according to the height of fall, the ground of fall, and the manner of death are summarized in **Table 2**. In terms of organ injuries, the most frequently affected organs are the lungs followed by the liver. The heart and aorta injuries were less commonly involved, except for homicide cases including stabbing in the chest. These visceral injuries increased proportionally with the height of the fall and were more observed for falls on solid ground, occurring independently of any skeletal injury. These characteristics are summarized in **Table 3**. As for homicide cases, the bodies were thrown into a well to prevent the body from being found, usually in wells distant from the victim's district.

Authors	n	Age distribution	Sex ratio	Manner of death	Cause of death	Well's characteristics
Dogan et al. (1)	18	Mean age : 40.4±20.6 [4-74]	8 (16M*/2F**)	Accidental (n=10)	- Intracranial hemorrhage - Asphyxia - Hemothorax (chest trauma) - Drowning	- Empty wells (n=10) - Wells filled with water (n=8) - Well's depth : 2m-30m
				Suicide (n=6)	-Drowning - Hemopneumothorax - Intracranial hemorrhage	
				Homicide (n=2)	- Pericardium tamponade - Strangulation	
Esiyok et al. (2)	69	Age ranging : [0-71], 33.4% (n=23) aged less than 10 years old	2.23 (47M/21F)	Not mentioned	- Drowning (n=28) - Polytrauma (n=19) - Asphyxia (n=11) - Toxicity (n=4) - Miscellaneous (n=4) - Unknown (n=13)	- Wells (n=40) - Sewer systems (n=9) - Water supplies, pits (n=6 each)
Cui et al. (3)	52	80.8% (n=42) aged between 20-50 years old,	0.40 (15M/37F)	Homicide (n=30) Suicide (n=20) Accidental (n=1)	- Mechanical injuries - Suffocation - Body surface abrasions - Drowning	- Well's diameter : 30-200cm - Well's depth: 2-20m

Mlayeh et al. (4)	72	Mean age 29±16.1 [3-88]	2.42 (51M/21F)	Suicide (n=52) Accidental (n=17) Homicide (n=3)	- Drowning - Polytrauma - Drowning - Polytrauma - Strangulation - Polytrauma	- Empty wells: 34 - Wells filled with water (n=37) - Well's diameter: 1-6m - Well's depth : 3-70m
M*: Male, F**: Female						

Table 1: Review of the literature on falls into wells.

	Skull	Cervival spine	Ribs	Thoracic spine	Lumbar spine	Pelvis	Upper limb	Lower limb
Less than 5	0%	0%	0%	0%	0%	0%	0%	0%
5 to 10	0%	0%	0%	0%	0%	0%	0%	0%
10 to 15	0%	0%	0%	0%	0%	0%	0%	0%
15 to 20	20%	0%	40%	20%	10%	10%	0%	0%
20 to 25	5%	0%	50%	0%	0%	0%	0%	0%
25 to 30	27.20%	9%	27.70%	0%	9%	9%	9%	9%
30 to 35	8.30%	4.10%	29.10%	20.80%	8.30%	16.60%	0%	12.40%
35 to 40	10%	10%	30%	20%	10%	10%	0%	10%
40 to 45	9.50%	9.50%	19%	9.50%	9.50%	33.30%	4.70%	4.70%
45 to 50	27.20%	9%	27.20%	9%	9%	18%	0%	0%
More than 50	26.30%	10.50%	21%	10.50%	0%	21%	0%	10.50%
Ground of fall								
Water	13.50%	8.10%	8.10%	0%	2.70%	13.50%	2.70%	5.40%
Soft ground*	54.50%	9%	72.70%	18.10%	36.30%	54.50%	0%	9%
Hard ground	47.80%	30.40%	91.30%	60.80%	43.40%	43.40%	4.30%	17.40%
Manner of death								
Accidental	29.40%	17.60%	41.10%	17.60%	17.60%	29.40%	0%	11.70%
Suicide	28.80%	13.40%	44.20%	23%	9.60%	26.90%	3.80%	9.60%
Criminal	66.60%	33.30%	66.60%	33.30%	33.30%	66.60%	0%	0%
* : mud, snow								

Table 2: Distribution of bone damages observed in fall into wells.

		Organ injuries	
		Yes	No
Ground of fall	Water	18.90%	81.10%
	Soft ground	100%	0%
	Hard ground	91.30%	8.70%
Cause of death	Strangulation	100%	0%
	Drowning	6.30%	93.80%
	Polytrauma	94.70%	5.30%
Manner of death	Accidental	58.80%	41.20%
	Suicide	51.90%	48.10%
	Criminal	100%	0%
Height of fall (m)	Less than 5	20%	80%
	05-Oct	16.70%	83.30%
	Oct-15	0%	100%
	15-20	67.30%	33.30%
	20-25	28.60%	71.40%
	25-30	40%	60%
	30-35	70%	30%
	35-40	40%	60%
	40-45	77.80%	22.2
	45-50	100%	0%
	More than 50	85.70%	14.30%

Table 3: Distribution of organ injuries following falls into wells.

Discussion

Dead bodies found in wells are a challenge for any forensic scientist, mainly because of the difficulty of establishing the manner of death, since death may have resulted from either a trauma before or as a result of the decedent landing in the well. Even in cases of drowning in wells, corpses may be damaged when hitting the sides of the well, when striking against intermediate obstacles (such as bricks, rocks, gangplanks), or when they make contact with the water surface. Identifying the bodies is also another challenge due to the putrefaction process that completely modifies the body's appearance and composition. The adipocire is a state when the fats of a body are transformed into a substance soapy whitish gray, greasy to the touch. It results from the saponification of the fat of the cadaver which occurs under certain circumstances, such as the presence of water, and an anaerobic environment (absence of oxygen) as is the case in the wells.

There are several reasons leading to the presence of a body in a well. According to our literary review, wells are a preferred locality for suicides. Suicide by jumping or precipitation seems to be a suicide mode of low frequency since it represents only 5% to 7% of all types of suicide [13,14]. This means of suicide is widespread in some countries such as Japan where jumping is the most common method of suicide after hanging, whereas in the United States, the most common methods are the use of a firearm, hanging and overdose [15]. An underlying psychiatric condition (schizophrenia, major depressive illness) is often found. People who attempt suicide by jumping from a height usually suffer from multiple injuries. These may be of two types: deceleration type injuries and direct impact injuries. The severity of these fall injuries depends on the height of the fall, body weight, speed, nature of the impacted surface, the orientation of the body at the time of impact, and the body part that hit the ground first. The height of the fall is a major determinant of injury [16] since the impact velocity is related to the distance of the fall by the equation V=√(2 gh) where v is the velocity at impact, g is the gravity constant of 32 feet/s2 (9.8 meters/s2), and h is the vertical distance of the fall [17]. The body position is also a crucial factor in the extent of injuries, through the angle of the fall as well as the position and the angle of impact. A vertical fall on the head, for example, with arms outstretched would result in fewer injuries than a horizontal or sideways fall, due to a smaller area of impact and a longer deceleration period [18]. Although a vertical impact is associated with higher kinetic energy and impact velocity, the pattern of injuries is different. According to Cui et al., suicide cases present more or less significant superficial injuries, mainly due to the confined space in which the body may tumble, to the complexity of projecting one's body in a straight free fall while being conscious, and to the friction that results in more or less significant abrasions when hitting the sides of the well. Such abrasions are relatively rare when a body is thrown into a well, such as in homicide cases since the limbs do not sway due to rigor mortis (i.e., stiffening of the body muscles caused by permanent biochemical transformations affecting muscle fibers after death). It is also interesting to note that the choice of the well can interfere in certain situations, especially in suicide cases who tend to choose deep wells without taking into account the nature of the receiving surface, given the ease of the act and the extreme nature of such suicide method. In these cases, the deceased often enters the well by the lower extremities first (free vertical fall), with the two upper extremities supporting the sides of the well, and releasing the hands when the majority of the bodyweight enters the well to fall by its own gravity [11].

According to some studies of falls from heights, the frequency of head fractures remains relatively constant in all height categories suggesting that height has a minimal effect on the frequency of head injuries [19] while other research reports that head injuries have a height-dependent pattern and predominate in falls from heights less than 10 m and greater than 30 m [16-20]. Our review of falls into wells showed that head injuries are height-dependent damages increasing proportionally with the height of the fall. Up to a fall of more than 50 m, the possibility of head injuries is higher either alone or in combination. These injuries would be expected to be less frequent when the receiving surface is mud, water, or snow at the bottom of the well, yet, head injuries are just as frequent. This could be explained by impacts on intermediate obstacles in high falls, or due to high velocity when entering the water with head-first attitudes. The heart is rarely damaged demonstrating the effectiveness of the rib cage as a protective mechanism comparing to abdominal organs having no such protective cover, resulting in a greater incidence of damage. Similar observations were reported by authors analyzing falls from a height, which deduced that as the height of fall increased, there was an increase in the incidence of internal injuries to the chest, abdomen, and fractures of the extremities [8-21].

Conclusion

Our literature review shows that fall into wells is a subject that requires more attention. Only a few articles have investigated these deaths. These falls are usually deadly with a low survival rate comparing to falls from heights. Due to the difficulties of finding and extracting the bodies, the decedents may remain in confined space resulting in disintegration and deterioration of human tissues, which explains why most of the cited articles were within the forensic domain. The pattern of injuries may also differ depending on the length of the fall, the depth of the well, the presence of the water at the bottom, and the manner of the death. In the lack of more comprehensive studies on the subject, the cause of death is determined with a body of evidence including crime scene evidence, witness statements, environmental characteristics, findings from an autopsy, and the results of histopathological, toxicological, and biochemical examinations together.

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