



## Injuries in fatal cases of falls downstairs

J. Preuß<sup>a,\*</sup>, S.A. Padosch<sup>a</sup>, R. Dettmeyer<sup>a</sup>, F. Driever<sup>a</sup>, E. Lignitz<sup>b</sup>, B. Madea<sup>a</sup>

<sup>a</sup>*Institute of Legal Medicine, University of Bonn, Stiftsplatz 12, D-53111 Bonn, Germany*

<sup>b</sup>*Institute of Legal Medicine, University of Greifswald, Kuhstraße 30, D-17489 Greifswald, Germany*

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### Abstract

Downstairs falls frequently occur within domestic environments and are mainly associated with elderly and intoxicated individuals, often feature multiple injuries on various parts of the body. In most cases it is not possible to determine the cause of the fall and/or death solely by means of external examination. In this retrospective study, which covers a period of 11 years, all cases of death which included a fall downstairs in their case history, were collected from the Forensic Institutes of the Universities of Bonn and Greifswald, Germany. Falls downstairs made up to 2% (166 cases) of all postmortem examinations carried out within this period. Interestingly, almost double of the amount of such falls applied to males as to females.

The primary cause of death was cranio-cerebral trauma and the vast majority of skull injuries associated with falls downstairs were found above 'the hat brim line'. Injuries were also often found on several other parts of the body at once. Nineteen of the 116 examined individuals exhibited agonal injuries. In these cases, postmortem examination revealed pre-existing disease or intoxication to be the cause of death and thus, cause of the fall. The injury pattern only allows a tendency towards vital or agonal incident as a conclusion.

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### 1. Introduction

In the literature, several publications on falls from high altitude exist [1–3]; however, only few authors have reported on the special issue of fatal falls downstairs [4].

In most cases, falls downstairs involve elderly and intoxicated individuals and frequently occur within a domestic environment [3,7].

If a lifeless individual is found in close proximity to a flight of stairs, a fall should be strongly suspected. Medical rescue teams, usually the first to arrive at the scene of such an incident, are, following initial examination, usually not able to determine whether death occurred as a result of sustained injuries or due to a so called 'agonal fall', subsequent to sudden death, e.g., due to a heart attack.

Release mechanisms for falls down or on stairs may fundamentally be regarded as acute occurrence or deterioration

of natural disorders (e.g., cardiac or cerebral syncope), accidents or third parties influence. Unless the latter leaves no isolated, defining and conclusive traces, a fall affected by third parties influence can hardly ever be verified [8,9]. Herein lies the essential forensic problem regarding falls downstairs as well as those from extreme heights [6,10,11].

The position of the injured or deceased individuals on or in relation to the stairs, possible areas of contact during the course of the fall, the use of glasses or walking aids and the condition of clothing provides information which can be of importance in clarifying the cause of the fall. Familiarity with injury patterns associated with falls downstairs, whereby the actual extent of a present injury is not immediately recognizable, is significant in the treatment of patients with non-fatal injuries.

In the majority of these cases, however, only autopsy and further forensic examination can provide more conclusive information as to the possible cause of the fall and its consequences [2,12]. However, the discrimination between fall or blow can be quite difficult in practical case work. To establish a final diagnosis in such cases, many factors have to

\* Corresponding author. Tel.: +49-228-73-83-41;

fax: +49-228-73-83-68.

E-mail address: [jpreuss@uni-bonn.de](mailto:jpreuss@uni-bonn.de) (J. Preuß).

be considered, whereas autopsy findings can be regarded of high importance.

The aim of this retrospective study, apart from describing typical injury patterns which are also of significance for attending physicians, was the investigation of classical causes of falls downstairs and associated fatalities. Furthermore, the analysis of possible surrounding circumstances (location, intoxication, gender, age) to provide a decision support for the investigation of falls downstairs in practical case work.

## 2. Materials and methods: subjects of research

All autopsy cases which had a history of fall downstairs and been subjected to postmortem examination performed by the Institutes of Forensic Medicine of the Universities of Greifswald (HGW) and Bonn (BN) between 1990 and 2000, were enrolled. In total, 116 cases were studied, of which Greifswald provided 57 and Bonn provided 59 cases for evaluation.

In detail, the autopsy reports were studied with regard to personal data of the victim (gender, age), cause of fall, cause of death and pattern of injuries, respectively.

## 3. Results

### 3.1. Circumstances

The proportional number of falls downstairs amounted to less than 2% of all performed autopsies. More than double the number of males than females were victims of such falls (males,  $n = 81$ ; females,  $n = 35$ ).

The age distribution (Fig. 1) clearly showed a maximum of cases amongst those between 50 and 60 years of age. A break down, according to age and gender, indicated that males between 50 and 60 years of age are the most frequent victims of falls downstairs. Amongst the females, eight victims were between 30 and 40 years of age and eight were between 50 and 60 years of age.

In 81 of those concerned (69.3%), blood alcohol concentrations (BAC) were determined. Higher levels of blood

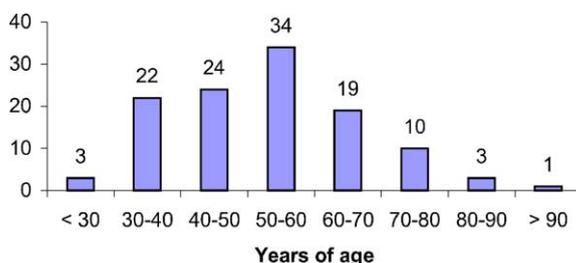


Fig. 1. Age distribution (frequencies).

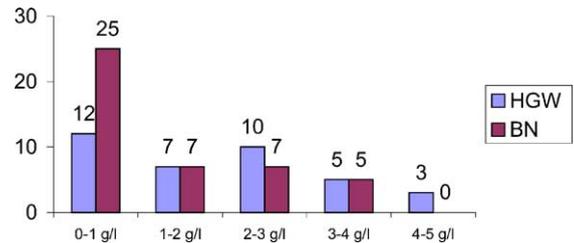


Fig. 2. Blood alcohol concentrations (frequencies).

alcohol concentrations (g/l) were observed in Greifswald (HGW) compared to Bonn (BN) (Fig. 2). In eight individuals, moreover, and according to anamnestic information, influence of alcohol was recorded without a BAC test being performed. As blood alcohol concentrations were not determined in all cases studied, it is to be expected that the number of individuals who were actually intoxicated at the time of falling was substantially higher. This, in many cases, provides a plausible reason for the fall.

The location of the fall was often not documented in closer detail. With regard to the type of stairs involved, insofar as this information was included in the autopsy protocol, it is apparent that domestic environments are the primary locations for such incidents (Table 1). The high number of falls down cellar stairs is conspicuous.

The victim's position at the scene was documented in 69 cases. Interestingly, the persons were found at the foot of the steps in 52 cases. Ten cases were documented whereby the body was located entirely upon the stairs. Three individuals were found with the upper body upon the stairs and four with their legs upon the stairs. Such information with regard to the remaining cases could not be extracted from the files. It is unknown if, when and in how many cases the position of the body was manipulated by emergency medical personnel.

### 3.2. Results of injuries

The injury pattern presented following a fall downstairs, is often polymorphic and usually involves several parts of the body. The explanation for this is secondary striking against a hard object, going head over heels and/or sliding on/over the steps. Injuries incurred whilst attempting to

Table 1  
Kinds of stairs (frequencies)

	Cases (n)
Cellar stairs	22
Wooden stairs	4
Stone stairs	11
House stairs	13
Unknown	34
Spiral staircase	2
Apartment stairs	15

Table 2  
Causes of death in medico-legal autopsy cases after lethal falls downstairs (frequencies)

	Cases (n)
Skull and brain injuries	77
Loss of blood	7
Cervical spine injuries	1
Intracerebral bleeding	2
Cardiac disease	14
Pneumonia/pulmonary embolism	10
Intoxications	5

break a fall can also form a part of the pattern. These injuries sustained are not always the cause of death. An analysis of the causes of death can be gathered from Table 2.

As shown in Table 2, injuries to the brain and skull are predominant amongst the fatalities.

Apart from the vital fall, the agonal and atonic falls should be differentiated terminologically and phenomenologically. Agonal injuries occur in the case of a fall during the course of death. The reason for this is, usually, a malcondition of the cardiovascular system (acute coronary insufficiency, heart attack). In these cases, injuries sustained during the fall do not contribute towards death. Falls at ground level, however, can also cause considerable damage and easily be misinterpreted as an act of violence per third party or as the actual cause of death.

The atonic fall is characterized by sudden loss of muscle tone or irregular tone distribution with disturbance of the stato-kinetic reflexes.

Lack of static reflexes may well cause severe facial injuries. This type of injury is also, due to the lack of reflexes, seen on the back of the hand rather than in the cup of the hand (Fig. 3). This type of fall, for example, can be observed as a cerebellar symptom in connection with intoxication. Atonic falls can also be characterized by a considerable severity of injuries.



Fig. 3. Atonic fall—skin abrasions on the back of the hand (lack of reflexory movement).

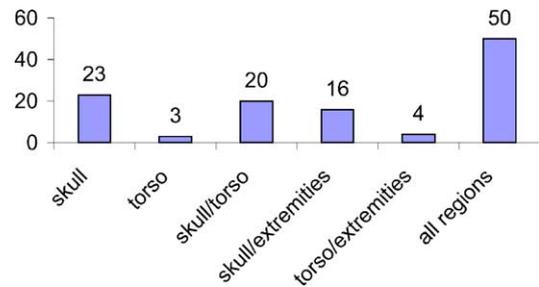


Fig. 4. Affected body regions—isolated and combined, skull including facial injuries (frequencies).

In 19 of the 116 examined cases (18%), trauma was not relevant to the cause of death; rather the presence of pre-existing disease and/or intoxication being the factor(s) leading to such. Twelve individuals died, despite medical treatment and hospitalization, succumbing, following varying periods of survival (days to month), to the typical after-effects of prolonged immobilization, such as pneumonia or pulmonary embolism (also heart attack), whereby the fulminant, sudden pulmonary embolism was also registered as a primary cause of falling.

Sustained injuries resulting from falls often affected several parts of the body (Fig. 4); the skull in 90.5%, the torso in 66.4% and the extremities in 60% of the cases. Moreover, 57.8% of the cases displayed facial injuries.

Only in 4% of the cases, crucially fatal injuries of the trunk were determined. In these cases it was the rupture of organs which led to internal haemorrhages and death; two ruptures of the liver, one rupture of the lungs and one comminuted fracture of the pelvis. In one case, a compound fracture of the upper arm with arterial damage was found to be the cause of death due to loss of blood.

### 3.2.1. Brain injuries and injuries of the viscerocranium

One hundred and five individuals collectively displayed skull injuries—fractures, lacerations, bruising/abrasions (Fig. 5).

Lacerations/abrasions/bruising of the back of the skull and the forehead region were found in 92 individuals. Only in 22 cases the victims exhibited injuries in both regions. In 32 cases, the above mentioned injuries were found isolated on the forehead and in 37 cases on the back of the head only.

Skull fractures were determined in 75 cases, the majority were basal skull fractures.

57% (67 cases) exhibited facial injuries. Out of these, 19 cases with lacerations (isolated and multiple), 63 cases with bruising and/or abrasions and 23 cases with fractures were observed. Multiple injuries were common.

In three cases, a combination of facial injuries and injuries of the torso without further damage to the skull were found. In one case, a combination of injuries of the face and extremities was determined. Two out of these four falls were agonal incidents, whereby autopsy revealed a cardiac

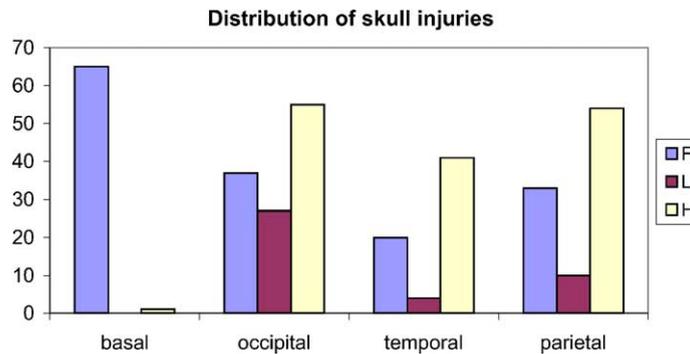


Fig. 5. F: fractures; L: laceration; H: haematoma (frequencies).

cause of death (e.g., ruptured transmural acute myocardial infarction). In the third case, subdural haemorrhage, despite a lack of external skull injury, was found to be the cause of death. The fourth patient survived for a period of nine days. The victim then died in hospital due to pneumonia with a acute pulmonary thrombembolism.

### 3.2.2. Injuries of the cervical vertebrae

Nine fall victims (7.8%) sustained fractures of the spine, of which the cervical vertebrae were affected in seven cases. However, only one of these fractures, together with a contusion of the cervical spinal cord, actually led to death. Fractures of the 5th and 6th cervical vertebrae were found in three cases.

Two victims of cervical vertebrae fracture died of a pre-existing heart disease. Examination results regarding the third case, coincided with the manner in which the fall occurred although the actual cause of death remained unclear.

Two cases exhibited a fracture of the 7th cervical vertebra. Isolated injuries of the cervical spinal cord without concomitant fractures of the cervical vertebrae were not found.

### 3.2.3. Injuries of the trunk

Seventy-seven individuals exhibited injuries of the trunk, whereby these often were only minor—such as bruising or abrasions. The fractures (Table 3) are made up of a surprisingly high number of rib fractures. These, however, often resulted from previous resuscitation efforts. The exact

Table 3  
Fractures of torso bones (frequencies)

Scapulae	Vertebral spine	Ribs	Pelvis	Total number of cases
+	–	–	–	3
–	+	+	–	3
–	+	–	–	6
–	–	+	–	20
–	–	–	+	1

number of these iatrogenic rib fractures could not be elucidated retrospectively.

Injuries as a direct result of resuscitation efforts are included in the report on rib fractures.

### 3.2.4. Injuries of the extremities

In about 60% of the cases, injuries of the extremities were found. These mainly involved the extensor regions of the extremities. Of the 57 fall victims with arm injuries, 49 exhibited damage to the extensor region only, three to the flexor region only and six to both the extensor and flexor regions of the arm. Thirty-eight fall victims sustained injuries of their legs. In these cases, injury of the extensor regions was also clearly emphasised (34 injuries of the extensor region only, three injuries of the flexor region only and one injury of the flexor and extensor region).

The extensor regions of the extremities are the typical points of contact in case of a fall, as are, for example, the knee caps and the elbows. Further typical injuries are wrist fractures, sustained in attempting to break the fall. These constitute the majority of fractures affecting the upper extremities. Sole fractures of the forearm and upper arm were found in two cases, respectively. Fractures of the long bones of the lower extremities were not documented in the autopsy reports studied.

### 3.2.5. Injuries of internal organs

In nine cases, injuries of thoracic (lung,  $n = 4$ ) and/or abdominal parenchymal organs (spleen,  $n = 3$ ; kidney,  $n = 2$ ; liver,  $n = 2$ ; intestine,  $n = 2$ ) were apparent.

Three individuals sustained multiple injuries. Likewise in three cases, death was caused by injuries of internal organs and massive haemorrhage.

## 4. Discussion

The retrospective analysis of 116 fatal falls downstairs revealed, that based on sole external examination of injury

patterns, no discrimination between agonal or vital injuries can be made. Remarkably, also persons who had fallen downstairs due to acute myocardial infarction or fulminant pulmonary embolism, partially exhibited severe injuries of various body regions, which thoroughly appeared as vital injuries. If at all, only an autopsy can determine the cause of death beyond doubt. The cause of death, however, and the cause of the fall may well be completely different. However, in practical case work the proof of a cardiac cause of death is a critical issue in cases of suspected agonal falls. Without any doubt, morphological findings, such as ruptures transmural myocardial infarction or fulminant pulmonary embolism prove these entities as the cause of death, hereby the fall can be classified as an 'agonal fall'.

In accordance with other authors, we found that males, as opposed to females, are clearly the most frequent victims of falls downstairs [3,5,10], moreover our data show, that acute intoxications represent a significant cause of fatal falls [3].

One question which arises with each fall downstairs is the definition of injuries caused by the fall as opposed to those caused by a blow [13]. This difference in definition can be particularly difficult when head injuries are involved. Because falls downstairs however, as shown in our study, are characterized by a high number of cranio-cerebral injuries, this question is of eminent significance [2,3,5]. As already mentioned before, the establishment of the final diagnosis, i.e. the discrimination between fall or blow is a crucial issue in practical case work. Careful examination of the circumstances at the scene, witness reports (if available), integral evaluation of external examination findings, most important autopsy and histologic findings, respectively, should enable the forensic pathologist to establish such a diagnosis.

Forensic science uses the so-called 'rule of the hat brim', according to which all injuries above the assumed hat brim can be attributed to a blow or a stroke and all injuries below this line can be attributed to a fall [13]. This rule, however, is primarily applied to falls at ground level. Interestingly, in accordance with previously published data [13], our study shows that the majority of skull injuries, especially lacerations occurring in association with a fall downstairs are above the brim (Fig. 5). These findings can be interpreted as an important exception from 'the hat brim rule', most probably due to reclination of the head or hitting the edge of the step.

However, in these cases with skull injuries above the hat brim line blows could be excluded after comprehensive and careful investigation of the scene and the environmental circumstances, respectively.

Results of cerebral examination can be helpful and often decisive for a correct interpretation when coup and contre-coup injuries are found [8,9,14–16].

In most cases, the problem of distinguishing between a fall or a blow can be solved by applying 'the hat brim rule' and accompanying orbital bone injuries, which have been found

in cases of falls on the back of the head, caused by means of contre-coup lesions through the eyeballs [8,9,14,15]. Here, both cerebral and orbital bone injuries often can only be recognized when an autopsy is performed.

The injury pattern will only reveal a tendency towards the fall being agonal or vital.

Injury patterns of previous falls can vary extremely. Unusual injuries or injuries which cannot immediately be diagnosed are always a possibility in association with falls downstairs. Primarily, cranio-cerebral traumas are found with varying levels of severity. 'Classical' blow and defensive injuries should be regarded with suspicion and recorded separately. Very frequently, the cause of death can not be determined by external examination only. In these cases, the attending physician or the coroner is well advised to express an opinion of 'unnatural death' or to declare the death as 'cause unknown' to ensure further medico-legal investigations.

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