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Discrimination of Falls and Blows in Blunt Head Trauma: Assessment of Predictability Through Combined Criteria*

ABSTRACT: The discrimination of falls from homicidal blows in blunt head injuries is a common but difficult problem in both forensic anthropology and pathology. Three criteria have been previously proposed for this distinction: the hat brim line rule, side lateralization of fractures, and number of lacerations. The aim of the present study was to achieve a better distinction rate by combining those criteria and assess the predictability of these combined criteria tools. Over a 6-year period, a total of 114 cases (92 males and 22 females) were studied: 21 cases of downstairs falls, 29 cases of falls from one's own height, and 64 cases of head trauma by a blunt weapon. The results revealed predictability rates varying from 62.5 to 83.3% for criteria pointing towards a fall. As for combined criteria in favor of a blow, the assumption was accurate in all cases (100%).

KEYWORDS: forensic science, blunt head trauma, hat brim line, skull fractures, lacerations, falls

The discrimination of falls from homicidal blows in blunt head injuries is a common but difficult problem in both forensic anthropology and pathology (1–5). One of the most often used criteria to evaluate this issue is the hat brim line (HBL) rule. According to this rule, an injury located above the HBL is more likely the result of a blow, while a fall would generally produce a wound at the level of HBL (1–5). However, a recent study has suggested that this rule may have to be reformulated: a wound located above HBL is suggestive of a blow, while a wound located inside HBL is less conclusive in the discrimination of falls from blows (6). In the literature, it is not clear if this rule applies to scalp lacerations, skull fractures, or both, and different authors have used it differently. The first objective of this study was to compare the validity of the HBL on lacerations and fractures.

Two additional criteria were proposed to assist in the distinction of falls from blows: the side lateralization of skull fractures (6) and the number of lacerations (2,6). While left-sided fractures are more in favor of blows, right-sided ones are more often associated with falls. It is not known if this lateralization criterion could also be applied for scalp lacerations; a second objective of this study was to evaluate this issue. As for the number of lacerations, a higher number of lacerations is more suggestive of blows, whereas falls generally present with less than three or four lacerations.

Nevertheless, it should be pointed out that those criteria, although useful, are only partly suggestive of the circumstances of injuries. As a matter of fact, at the present time, it is impossible to be absolutely confident in the distinction of falls from blows by basing oneself solely on those criteria. Therefore, the third objective of this study was to achieve a better distinction rate by combining criteria and assess the predictability of these combined criteria tools.

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Materials and Methods

For a 6-year period (2000–2005), all autopsy cases from the Montreal Laboratoire de sciences judiciaires et de médecine légale were analyzed. Cases selected consisted of falls downstairs, falls from one's own height, and head trauma by a blunt weapon. Designation of cases as falls or blows was not solely based on head examination but on a thorough case review, including scene investigation, witness testimony, perpetrators' confession and other autopsy findings. In homicidal blows, cases involving a victim struck while lying on the ground were excluded. Upon review of photographs and autopsy reports, all cranial fractures and lacerations were positioned on figures representing the head and the skull in different anatomical views. Facial lacerations and fractures were not considered in the present study.

HBL was defined according to the previous definition of Kremer et al. (6): the area located between two lines parallel to a line inspired by the Frankfort horizontal plane (horizontal plane passing through right and left porion points and the left orbitale), the superior margin passing through the glabella (G line) and the inferior margin passing through the center of the external auditory meatus (EAM line) (Fig. 1).

For each case, the following elements were compiled: number of lacerations, location of lacerations and fractures in relation to HBL, and side lateralization of skull fractures. When multiple lacerations were present, the location of lacerations in relation to HBL was assessed as the zone containing the highest number of lacerations. Furthermore, if some lacerations were overlapping two zones (i.e., an injury extending both in and above HBL), they were counted in the area of their main location. Finally, the SPSS 15.0 software (SPSS Inc., Chicago, IL) was used to perform statistical analyses, using cross-tab analysis.

Results

Over a 6-year period, a total of 114 cases (92 males and 22 females) were selected: 21 cases of downstairs falls, 29 cases of falls from one's own height, and 64 cases of head trauma by a

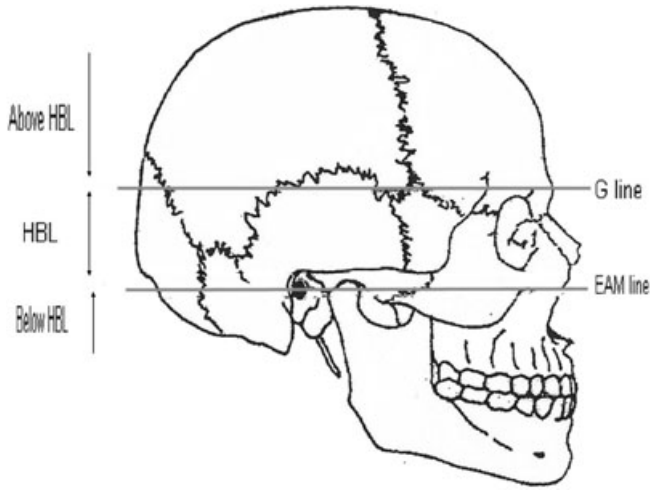

FIG. 1—*Schematic representation of the HBL.*

blunt weapon. Mean age was relatively similar in each category: 50.1 (±14.3 years) in cases of falls downstairs, 51.5 (±17.5 years) in cases of falls from one's own height, and 44.6 (±20.1 years) in blows cases. As for gender, there was a male predominance in all categories: male:female ratio of 6:1 for downstairs falls, 8.7:1 for falls from one's own height, and 3:1 for blows.

Of the 114 cases, 71 cases presented skull lacerations (54 cases of head blows, nine cases of falls downstairs, eight cases of falls from one's own height) and 87 cases, skull fractures (54 cases of head blows, 12 cases of falls downstairs, 21 cases of falls from one's own height). Fourteen cases were not associated with lacerations nor vault fractures (four cases of head blows, four cases of falls downstairs, six cases of falls from one's own height).

HBL Rule

Lacerations located inside HBL were mostly because of falls (66.7%), whereas lacerations positioned above HBL were more often related to blows (76.4%) (Table 1). However, it should be mentioned that the majority of lacerations were positioned above HBL, in cases of blows (42 cases out of 44) as well as in fall cases (13 out of 17). Therefore, it is not surprising that the correlation between the position of a laceration in relation to HBL and the circumstances of death was rather weak ($\alpha = 0.03$, contingency coefficient = 0.27).

As for cranial fractures, the location of a fracture inside HBL was of little interest in the distinction of falls from blows. As a matter of fact, 50% of fractures located inside HBL were caused by falls and 50% by blows (Table 1). On the other hand, fractures located above HBL were associated to blows in 75.9% and to falls in only 24.1%. Hence, a fracture positioned above HBL was in favor of a blow. Nevertheless, the correlation factor for this isolated variable was still weak ($\alpha = 0.02$, contingency coefficient = 0.25).

TABLE 1—*Lacerations and fractures in relation to HBL in falls versus blows.*

	Lacerations		Fractures	
Circumstances	HBL, *n* (%)	Above HBL, *n* (%)	HBL, *n* (%)	Above HBL, *n* (%)
Falls	4 (66.7)	13 (23.6)	24 (50.0)	7 (24.1)
Blows	2 (33.3)	42 (76.4)	24 (50.0)	22 (75.9)

HBL, hat brim line.

TABLE 2—*Lateralization of lacerations and fractures in relation to circumstances of death.*

	Lacerations		Fractures	
Circumstances	Right, *n* (%)	Left, *n* (%)	Right, *n* (%)	Left, *n* (%)
Falls	5 (71.4)	1 (14.3)	13 (56.5)	5 (19.2)
Blows	2 (28.6)	6 (85.71)	10 (45.3)	21 (80.8)

Side Lateralization

Lacerations on the right side of the head were more commonly associated with falls (71.4%), while left-sided lacerations were more likely the result of blows (85.7%) (Table 2). Cross-tabs test between side lateralization of lacerations and circumstances of death revealed a significant correlation between those variables ($\alpha = 0.03$, contingency coefficient = 0.50).

Side lateralization of fractures was also of interest in the distinction of falls from blows: right skull fractures were more likely to result from falls whereas left skull fractures were more often associated with blows ($\alpha = 0.007$, contingency coefficient = 0.36) (Table 2).

Number of Lacerations

In fall cases, the average number of lacerations per case was of 0.49 (range of 3, SD of 0.79). In blow cases however, the average number was of 4.41 lacerations per case (range of 22, SD of 4.41). The relation between the number of lacerations and the circumstances of death, as measured by cross-tabs test, was significant ($\alpha = 0.000$, contingency coefficient = 0.48). As a matter of fact, cases presenting three or less lacerations were mostly falls cases (60.5%). Even more interesting, all cases (100%) with more than three lacerations were cases of blows (Table 3).

Combined Criteria Tool

Considering the previous results, the presence of a fracture above HBL, of a left side lateralization of skull fractures, and the presence of more than three lacerations are criteria in favor of a blow. On the contrary, a typical fall case is more likely to present with a fracture inside HBL, a right side lateralization of skull fractures, and three lacerations or less. The predictability of the presence of any two of those criteria was then assessed (Table 4).

TABLE 3—*Number of lacerations in relation to circumstances of death.*

	Number of Lacerations	
Circumstances	Three or Less, *n* (%)	More than Three, *n* (%)
Falls	49 (60.5)	0 (0.0)
Blows	32 (39.5)	32 (100.0)

TABLE 4—*Predictability of two criteria out of three to evaluate circumstances of death.*

Circumstances	Two Criteria in Favor of a Fall, *n* (%)	Two Criteria in Favor of Blows, *n* (%)
Falls	27 (65.9)	0 (0.0)
Blows	14 (34.1)	20 (100.0)

TABLE 5—*Predictability of the combination of two criteria to evaluate circumstances of death.*

	Relation to HBL + Side Lateralization (α = 0,002, Contingency Coefficient = 0.52)		Side Lateralization + Number of Lacerations (α = 0, Contingency Coefficient = 0.60)		Relation to HBL + Number of Lacerations (α = 0, Contingency Coefficient = 0.55)	
Circumstances	In favor of falls, *n* (%)	In favor of blows, *n* (%)	In favor of falls, *n* (%)	In favor of blows, *n* (%)	In favor of falls, *n* (%)	In favor of blows, *n* (%)
Falls	10 (62.5)	0 (0.0)	13 (76.5)	0 (0.0)	24 (72.7)	0 (0.0)
Blows	6 (37.5)	9 (100.0)	4 (23.5)	12 (100.0)	9 (27.3)	13 (100.0)

HBL, hat brim line.

TABLE 6—*Predictability of the combination of three criteria to evaluate circumstances of death.*

Circumstances	Three Criteria in Favor of Falls,* *n* (%)	Three Criteria in Favor of Blows,† *n* (%)
Falls	10 (83.3)	0 (0.0)
Blows	2 (16.7)	6 (100.0)

HBL, hat brim line.
*Fractures in HBL, right-sided fractures, and three lacerations or less.
†Fractures above HBL, left-sided fractures, and >3 lacerations.

The presence of at least two criteria in favor of a fall was successfully predicting cases in 65.9%. Moreover, the presence of at least two criteria in favor of a blow revealed a perfect score of 100% of successful prediction. The contingency coefficients for the three different combinations of criteria are presented in Table 5.

By combining the three criteria altogether, the predictability of the criteria tool was even better (Table 6): the presence of a combination of three criteria in favor of blows still demonstrated a success rate of 100%, while the success rate for falls reached 83.3% with the combination of a fracture in HBL, a right side lateralization of fractures, and a small number of lacerations (three or less) (α = 0.001, contingency coefficient = 0.62).

Discussion

Forensic experts, when confronted to blunt head trauma, are often asked to determine if the trauma is related to a fall or induced by homicidal blows. In order to resolve this common problem, forensic experts must rely on a thorough case investigation including scene examination, review of witness report (if available) and, most importantly, a complete autopsy. Nevertheless, this discrimination of falls from blows remains a challenge, mainly because of a lack of systematically established reliable criteria. To palliate this problem, three criteria have been proposed in the present study and combined to develop a criteria tool. As far as the authors know, this is the first time such a tool is offered to the forensic community.

HBL Rule

According to the HBL rule, a wound located above the HBL is more likely to result from a blow while a wound located inside the HBL is more often related to a fall (1–5). However, there are three main problems with this rule: (i) a poor standardization of the anatomical landmarks of the HBL, (ii) a confusion if it applies to fractures, lacerations, or both, and (iii) a paucity of studies evaluating the validity of this criterion.

Several definitions of the HBL have been proposed, some very general and poorly replicable, others more precise but not applicable on a dry skull. As a matter of fact, definitions such as "prominent areas of the head, like the forehead, the occipital pole and a line bridging these areas" (4) and "the level where the brim of a hat would lie" (1,5) are not precise enough to be replicable. A more precise definition has been proposed by Erhlich and Maxeiner: a band-like area of approximately 3 cm whose lower limit ran from the top of the eyebrows, around the upper margin of the auricle, and along the occipital pole at the back (2). Although this definition is anatomically precise, its application in forensic anthropology may be problematic on a dry skull, by absence of ears and eyebrows. In the present study, we used the definition proposed previously in Kremer et al. in 2008: the HBL corresponds to the area located between two lines parallel to a line inspired by the Frankfort horizontal plane (horizontal plane passing through right and left porion points and the left orbitale), the superior margin passing through the glabella (G line) and the inferior margin passing through the center of the EAM line. Since the HBL is defined as a band-like area passing between two lines, the traditional term of HBL is now a misnomer and maybe the term "Hat Brim Band" or "Hat Brim Lines" would be better names. To avoid changing the established appellation too much, we suggest simply using the plural form of "Hat Brim Lines" (HBL).

Although the HBL rule is mentioned in several important textbooks (1,4,5), very few studies have evaluated its validity. Furthermore, there seems to be some confusion if this rule applies to head lacerations, skull fractures, or both. As a matter of fact, only two previous studies have compared falls and blows cases in relation to the HBL in order to determine the validity of this rule. In the first one, by Erhlich and Maxeiner in 2002, 203 falls on a flat surface and 51 falls downstairs were compared with 51 blows (2). They observed that lacerations from blows occur more often (55%) above the HBL, than lacerations from falls. Still, about a third of lacerations in falls cases were located above HBL. In the second study, 23 falls from one's own height and 13 falls downstairs were compared with 44 blows (6). The conclusion of this last study, concentrating this time on the location of skull fractures rather than lacerations, also reveals that injuries from blows are more often found above HBL. However, the presence of a fracture inside the HBL was less conclusive as the circumstances.

The present study is the first to compare the HBL predictability of head lacerations and skull fractures. Those results confirm that a laceration or a fracture located above the HBL is in favor of a blow, with very similar predictability rates (76.4% of lacerations and 75.9% of fractures located above HBL are related to blows). As for injuries located inside HBL, a laceration seems to be slightly more informative than a fracture as the circumstances. Indeed, a laceration inside HBL is slightly more in favor of a fall (66.7%), while a skull fracture inside HBL is found in 50% of falls and 50% of blows.

Side Lateralization

Side lateralization was first proposed as a new criterion in the discrimination of falls from blows in a previous study by Kremer et al. (6): a left skull fracture is more often related to a blow, while a right skull fracture is more in favor of a fall. This could be explained in cases of blows by the fact that most perpetrators are right-handed. As for the underlying explanation of right side lateralization of fractures, it may once again be explained that since most persons are right-handed, their first protection when falling is to try to interpose their right hand and therefore, the right side of the head is more prone to hit the ground. In the present study, lateralization of lacerations was also found to be useful.

Number of Lacerations

Lacerations in ground-level falls are known to be uncommon, external injuries being limited to scalp contusions or abrasions in most cases (7). It then comes as no surprise that the number of lacerations was previously proposed as a criterion in the distinction of falls from blows. Ehrlich and Maxeiner were first to demonstrate that all falls are associated with a small number of lacerations (four or less), while most cases of blows presented multiple lacerations (2). This was later confirmed by Kremer et al. (6). Of the three criteria presented in the present study, the number of lacerations is the one presenting the higher contingency coefficient and therefore, the higher predictability rate.

Combined Criteria Tool

By combining the three previous criteria, a tool was then developed. If three criteria point towards a fall, this assumption was correct in 83.3% of cases. As for the combination of three criteria in favor of a blow, the assumption was accurate in 100% of cases. If only two criteria out of three are in favor of a given circumstance, predictabilities vary from 62.5 to 76.5% in combinations pointing towards falls cases and remain 100% for all combinations in favor of a blow (Table 5). Although those results are highly interesting, it should be mentioned that further research is needed before using those predictability rates in assessing a specific case. Nevertheless, the combined criteria tool may still be of some help in the difficult challenge of discriminating falls from blows in the day to day practice.

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