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Discrimination of Falls and Blows in Blunt Head Trauma: Systematic Study of the Hat Brim Line Rule in Relation to Skull Fractures

ABSTRACT: In the discrimination of falls from blows in blunt head trauma, the hat brim line rule is one of the most often used criteria. The present study assesses the validity of the hat brim line rule for skull fractures and looks at other possible criteria. All autopsy cases were retrospectively analyzed on a 5-year period. Cases selected consisted of downstairs falls (n = 13), falls from one's own height (n = 23), and homicidal blows (n = 44). Results show that fractures above the hat brim line are more in favor of blows, while fractures in the hat brim line zone are more difficult to distinguish. The majority of fractures were located on the left side for homicidal blows and on the right side for falls. A higher average number of lacerations was revealed for homicidal blows. In conclusion, this study establishes three criteria in favor of blows: (i) localization of a wound above the hat brim line; (ii) left side lateralization; and (iii) a high number of lacerations.

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

Forensic experts, when confronted with deaths by blunt force injuries to the head, are often asked to determine whether the trauma is related to a fall or induced by homicidal blows. Though this issue is a common problem in forensic pathology and anthropology (1–3), few criteria have been studied and validated to assist in this distinction.

One of the most often used criteria in the discrimination of falls and blows is the hat brim line rule: an injury located above the hat brim line is more likely the result of a blow, while a fall would generally produce a wound at the level of the hat brim line (1,2). According to Ehrlich and Maxeiner (2), the hat brim line corresponds to 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. Unfortunately, very few studies have systematically evaluated the reliability of this commonly used criterion. Moreover, in forensic anthropology, the application of this criterion to the study of the dry skull can become rather problematic.

This study was thus undertaken to analyze and systematically compare localization of cranial fractures and number of lacerations on the scalp in cases of downstairs falls, falls from one's own height, and blunt weapon blows. The objectives of this study were to assess the validity of the hat brim line rule for skull fractures and to look at other possible criteria in the discrimination of falls from blows.

Materials and Methods

For a 5-year period (2000–2004), 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. In blunt force trauma to the head, cases involving a victim struck while lying on the ground were excluded. Upon review of photographs and autopsy reports, all cranial fractures were positioned on figures representing the skull in different anatomical views. Furthermore, all cases were analyzed in terms of number of lacerations.

In this study, the hat brim line was defined in order to be applicable to a skull without soft tissues. Thus, precise anthropometric landmarks of the skull were used. An inferior margin parallel to a line inspired by the Frankfort horizontal plane (horizontal plane passing through right and left porion points and the left orbitale) (4) and passing through the center of the external auditory meatus was traced (EAM line). A superior margin parallel to a line inspired by the Frankfort horizontal plane and passing through the glabella was also traced (G line). Using these margins, two skull sections were defined: the area between the EAM line and the G line (hat brim line) and the area located above the G line (above hat brim line).

The SPSS 15.0 software (SPSS Inc., Chicago, IL) was used to perform statistical analyses of correlation between the established variables.

Results

In a 5-year period, a total of 80 cases were selected: 13 cases of downstairs falls, 23 cases of falls from one's own height, and 44 cases of head trauma by a blunt weapon. Of these, a total of 72 cases presented skull fractures, while the remaining (n = 8; 2 blunt weapon trauma, 2 falls downstairs, and 4 falls from one's own height) did not. Cases of falls downstairs revealed a male:female ratio of 12:1 with an average age of 48 (±16.8 years), while the ratio for falls from one's own height was 6.7:1 with an average age of 49 (±17.2 years). Cases of blunt force trauma to the head showed a male:female ratio of 3:1 with an average age of 41 (±20.5 years).

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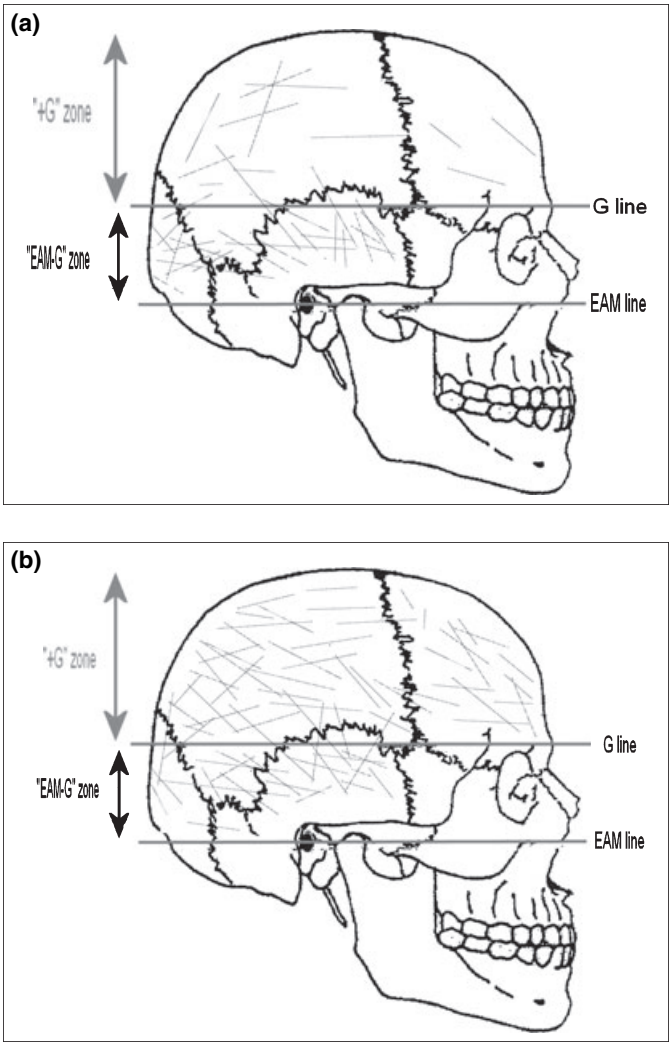

FIG. 1—*Schematic presentations of cranial fractures localization in relation to the hat brim line. Fractures are represented from a lateral view combining right and left on a same scheme. (a) Falls from one's own height or downstairs. (b) Hits by a blunt weapon.*

Hat Brim Line Rule

Falls versus Blows—Pearson's chi-squared test showed a significant correlation between circumstances of cranial fractures and their relation to the hat brim line ($\alpha = 0.053$, contingency coefficient = 0.24). As a matter of fact, when looking at cases of falls in general, fractures were mostly concentrated in the hat brim line (Fig. 1). In cases of blunt weapon blows, however, fractures did not present this hat brim line concentration and, in several cases, fractures were found in the hat brim line and above it as well. Therefore, the presence of a fracture in the hat brim line zone is of little use as a criterion to distinguish falls from blows. On the other hand, the presence of a fracture above the hat brim line is in favor of blows. As a matter of fact, blows represent 72.0% of fractures appearing above the hat brim line (Table 1).

Falls: Downstairs versus from One's Own Height—Pearson's chi-squared test did not reveal a significant correlation between circumstances of falls and their relation to the hat brim line ($\alpha > 0.5$).

TABLE 1—*Localization of cranial fractures based on circumstances of death.**

	Hat Brim Line Only	Above Hat Brim Line
Circumstances	*n* (%)	*n* (%)
Falls	20 (52.6)	7 (28.0)
Blunt weapon hits	18 (47.4)	18 (72.0)

*Fractures found in and above the hat brim line were excluded. The total of cases here presented is therefore <72.

TABLE 2—*Side of cranial fractures by circumstances of death.*

	Right Side	Left Side
Circumstances	*n* (%)	*n* (%)
Falls	13 (76.5)	4 (23.5)
Blunt weapon hits	7 (31.8)	15 (68.2)

Side Lateralization

Falls versus Blows—In cases of side skull fractures, a Pearson's chi-squared test revealed a significant correlation between circumstances of death and the side of the skull wounded ($\alpha = 0.006$, contingency coefficient = 0.41). Indeed, in both types of falls, fractures were mostly detected on the right side of the skull, while this preferential right lateralization was not observed with head trauma by a blunt weapon (Table 2). As a matter of fact, a left fracture was more suggestive of head trauma by a blunt weapon.

Falls: Downstairs versus from One's Own Height—On the other hand, side lateralization was not a useful criterion ($\alpha > 0.5$) in the distinction between type of falls, as both types were more frequently found on the right side. Thus, it is not possible to determine the type of fall solely based on the localization of the fracture.

Lacerations

Falls versus Blows—Over half of fall cases (60.0%, 21/35) had no laceration on the scalp, while only 9.3% of cases (4/43) involving blunt weapon trauma showed no laceration. Once again, Pearson's chi-squared test demonstrated a strong relationship between circumstances of fractures and the number of lacerations observed on the scalp ($\alpha = 0.000$, contingency coefficient = 0.60). Both types of falls led to fewer lacerations than blows by blunt weapons. In fall cases, a maximum of three lacerations was observed (average = 1, SD = 1), while blows, on average, caused five lacerations (SD = 4). In fact, it is highly interesting to note that all falls showed three lacerations or less (35/35 cases), while only 41.9% (18/43) of blows had three lacerations or less (Table 3).

Falls: Downstairs versus from One's Own Height—However, the number of lacerations on the scalp cannot help differentiate between falls downstairs and falls from one's own height ($\alpha = 0.19$).

Discussion

The discrimination of falls from blows in blunt head trauma is a crucial issue in practical case work. To resolve this problem, forensic experts must rely on a thorough case investigation including

TABLE 3—*Number of lacerations based on circumstances of death.**

Number of Lacerations	Falls	Blunt Weapon Hits
0	21	4
1	10	3
2	2	7
3	2	4
4	0	6
5	0	4
6	0	1
7	0	3
8	0	3
9	0	3
>10	0	5
Total	35	43

*In one case of each category, postmortem decomposition was too advanced to allow assessment of lacerations.

scene examination, review of witness report (if available) and, most importantly, a complete autopsy. However, this differentiation of falls from blows is particularly difficult, mainly because of a lack of systematically established reliable criteria.

Hat Brim Line

In the forensic literature, the definition of the hat brim line is poorly standardized. In the English literature, one textbook refers to prominent areas of the head, like the forehead, the occipital pole, and a line bridging these areas (5). In other textbooks, the hat brim line has been described as the level where the brim of a hat would lie (1,6). In the German forensic literature, the hat brim line has been defined as the greatest horizontal head circumference (7). In 2002, Ehrlich and Maxeiner (2) extended this definition to 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. When applied to forensic anthropology, the latter can be problematic as, more often than not, ears and eyebrows are absent. With this study, a definition of the hat brim line based on specific anatomical landmarks that can be easily located on a human skull was established. Indeed, by defining an area between the G line and the EAM line, the authors introduce a hat brim line corresponding to this G–EAM zone that is easily applicable to both forensic anthropology and pathology.

Our results reveal that fractures above the hat brim line are more in favor of blows, while fractures found only in the hat brim line (G–EAM zone) are more difficult to distinguish. These results are in keeping with the 2002 study by Ehrlich and Maxeiner (2). The latter retrospectively reviewed 305 cases in a 20-year period: 203 falls on a flat surface, 51 falls downstairs, and 51 blows. They evaluated head injuries, with restriction to lacerations, and observed that injuries from blows occur more often (55%) above the hat brim line, than injuries from falls. Still, their results also revealed that about a third of lesions caused by falls were located above the hat brim line (2). Fractures were not evaluated.

In 2004, Preuss et al. (3) studied 116 cases of falls downstairs, including 105 cases of head injuries and 75 cases of skull fractures. Fractures were mostly found in the parietal and occipital bones. In their discussion, they state that their findings could be interpreted as an exception from the hat brim line rule. However, they did not specify the exact location of fractures on those bones (e.g., inferior or superior part of occipital bone). Therefore, we do not think that a statement considering the position above or in the hat brim line could be performed on the basis of only bone fractures locations. As a matter of fact, the occipital bone is at the same time partly above and partly in the hat brim line zone, while the parietal bones, though mostly above the hat brim line, are nevertheless partly within. This problem reinforces the necessity to standardize the definition of the hat brim line and to apply it with caution.

Side Lateralization

In the present study, side lateralization of fractures revealed to be quite interesting in the distinction of falls from blows. As a matter of fact, the majority of fractures induced by blows were located on the left side of the skull, while the right side was predominant for fall fractures. 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 as most person 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. Considering our relatively small number of cases of falls with fractures, it would be interesting to study the side lateralization of fractures on a much larger population. As far as we know, this aspect has not been studied before.

Lacerations

When looking at the number of lacerations, our results show a higher number of lacerations for blows compared to falls. With an average number of five lacerations for blows and <3 for falls, our results confirm those of Ehrlich and Maxeiner (2) where all falls presented with four lacerations or less, while most cases of blows presented multiple lacerations. More precisely, it can be said that 47% (24/51) of their cases of blows presented four lacerations or less. Our study revealed that 41.9% of cases of blows presented three lacerations or less.

Conclusion

Overall, this retrospective study first introduced a new definition of the hat brim line, based on standard anatomical landmarks that are easily found on a dry skull. The application of the hat brim line rule in forensic anthropology is thus facilitated by our G–EAM zone.

In terms of the validity of the hat brim line rule, this study suggests that it should be applied with caution. In fact, a fracture found in the hat brim line zone is less conclusive than above it.

Finally, in the discrimination of falls from blows at autopsy, the authors would like to propose the following criteria based on this study:

1. Localization of a wound above the G–EAM zone (hat brim line) for blows.
2. Side lateralization: left for blows and right for falls.
3. Higher number of lacerations for blows than for falls.

Needless to say, those criteria should never be taken in isolation to the other autopsy findings and crime scene examination.

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