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Bleedings into the Anterior Aspect of the Intervertebral Disks in the Lumbar Region of the Spine as a Diagnostic Sign of Hanging

ABSTRACT: Simon's hemorrhages are ventral intervertebral hemorrhages located beneath the anterior longitudinal ligament that have been described in cases of hanging and tend to appear in the lumbar region of the spine. There are also reports of Simon's hemorrhages in cases of blunt trauma, asphyxia, drowning, and putrefaction. In a prospective analysis of 2226 autopsies, we found Simon's hemorrhages in 65 out of 178 cases of hanging and also in 17 cases in a group of 350 controls with various causes of death. The relative frequency of occurrence of Simon's bleedings in cases of hanging was 37%. Simon's hemorrhages can be considered an objective vital finding, which is not absolutely specific for hanging. The absence of hemorrhages in intervertebral disks does not exclude death by hanging. This study suggests that Simon's bleedings in cases of hanging are more frequent in rather young individuals, in cases with free body suspension, and in individuals with minimal degenerative changes in the lumbosacral part of the spinal column.

KEYWORDS: forensic science, hanging, Simon's bleedings, vital sign, autopsy, spine

Hemorrhages beneath the area of the anterior longitudinal ligament of the intervertebral disks in the lumbar vertebrae were first described in cases of death by hanging by the German forensic pathologist Axel Simon in 1968 (1,2). In his honor, medicolegal literature calls this morphological finding Simon's bleedings (Simon's sign or symptom; Ref. 3–7). Simon's bleedings look like dark red to violet lines between vertebral bodies of the lower thoracic and lumbar spine (Fig. 1); they are limited only to the area of the anterior ligament of intervertebral disks and do not penetrate into the vertebral bodies (1). It is necessary to point out that these hemorrhages occur not only in cases of hanging, but also infrequently in other cases of nonnatural death—e.g., traffic accident injuries, falls from heights, drowning, hypothermia, etc. (8–11). Simon's bleedings in cases of natural death are extremely rare (8). A differential diagnosis between Simon's hemorrhages and putrefactive changes is not possible even after a histological examination (8). The objective of our study was to consider the objective diagnostic value of Simon's hemorrhages in cases of death by hanging and to contribute to the understanding of the circumstances in which these bleedings occur.

Materials and Methods

We set up a prospective, consecutive, and continuous group of cases of hanging from autopsies carried out at the Institute of Legal Medicine in Hradec Králové within the period of 2005–2007 (36 months in total). The entire group comprised suicide cases with the exception of one accident. In the given time period, a total of

2226 autopsies were carried out, out of which there were 185 cases of hanging; 7 cases of hanging were excluded because of advanced putrefaction. The continuous control group contained 350 subjects who had died of various natural and nonnatural deaths (only cases without putrefactive changes). Deaths in the controls were attributed to a variety of natural causes (including pulmonary embolism, pneumonia, ischemic heart disease, aortic dissection, asthma) and nonnatural causes (including traffic accidents, falls, hypothermia, stabbing, gunshot wounds).

Hemorrhages into the anterior aspect of the intervertebral disks in the lumbar region, or possibly in the other regions of the spinal column as well, were evaluated macroscopically after removal of the intra-abdominal organs. For better transparency, lumbar muscles and soft tissues above bodies of particular vertebrae were cut out. At the same time, degenerative changes in the lumbosacral part of the spinal column were evaluated and categorized into three groups according to their degree of severity (none, moderate, severe). Prior to the study, we presumed that the higher the degree of degenerative changes in the lumbosacral part of the spinal column, the lower the relative frequency of the occurrence of Simon's sign.

The statistical analysis was carried out using the chi-square test for contingency tables and logistic regression to see whether any dichotomous variables depended on quantitative ones. A *p*-value <0.05 was considered significant and <0.001 as highly significant. Calculations were performed with the NCSS program using Windows.

Results

The analyzed group consisted of 178 cases of hanging. Only one case of the group was an accident (autoerotic asphyxial manipulation). The other cases were suicides only. In the group of 178 cases of hanging, there were 150 males (84%) and 28 females (16%),

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FIG. 1—Simon's hemorrhages into the anterior aspect of the intervertebral disks in the lumbar region of the spine (complete hanging).

aged between 14 and 94 years. The average age of the individuals was 50 years.

In the 178 evaluated cases, the relative frequency of occurrence of Simon's hemorrhages was proved to be 37% (65 cases). The finding was present in 53 males (35% of all males in the group) and 12 females (43% of all females in the group). The relative frequency of occurrence of hemorrhages in cases of the control group was evaluated as insignificant and occurred only in 17 cases of violent death (a relative frequency of 5% in the control group). This included 12 cases of traffic accident injuries—collision of a car with a pedestrian in a fronto-dorsal or fronto-lateral key position (7 cases), a crash of a motorcycle driver against a solid obstacle (3 cases), and a collision of a pedestrian with a train in a fronto-dorsal key position (2 cases). The other 5 cases with a positive occurrence of Simon's bleedings included hypothermia (2 cases), positional asphyxia (1 case), and drowning (2 cases). In our control group, Simon's bleedings did not occur in cases where the cause of death was natural.

The occurrence of hemorrhages was more frequent in cases of free suspension hanging without mechanic support of the body than in cases with incomplete suspension of the victim. In the former case, that of free suspension, the relative frequency of Simon's bleedings occurring was 46% (52 positive cases out of 112), whereas in the latter case, that of incomplete suspension, the relative frequency was 20% (13 positive cases out of 66). The age in the free suspension group was distributed the same way as the age in the incomplete suspension group (we used an unpaired *t*-test, Mann-Whitney test, and Kolmogorov-Smirnov test). A highly significant association between the occurrence of hemorrhages in cases of hanging and free body suspension was confirmed by a chi-square test ($p < 0.001$). However, a significant association between

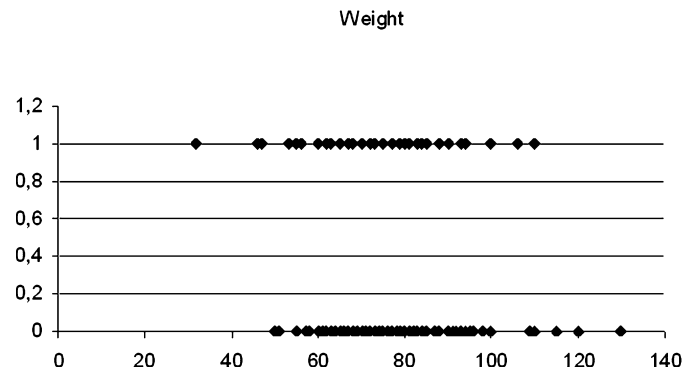


FIG. 2—Association between the occurrence of hemorrhages into the anterior aspect of the intervertebral disks and the victim's weight. A significant association between the victim's weight and positive occurrence of hemorrhages was not confirmed (logistic regression, $p = 0.123$).

the victim's weight and the positive occurrence of hemorrhages was not confirmed by logistic regression testing ($p = 0.123$, Fig. 2).

Simon's hemorrhages were rare in individuals with severe degenerative changes in the lumbosacral part of the spinal column. The more severe the degenerative changes of the spine were, the lower the relative frequency of the occurrence of Simon's hemorrhages. In individuals with the most severe degenerative changes in the lumbosacral part of the spinal column (21 individuals in total, 12% of the group), hemorrhages occurred in only one case. A highly significant association between degenerative changes in the lumbosacral part of the spinal column spine and the absence of Simon's hemorrhages in cases of hanging was confirmed by a chi-square test ($p < 0.001$).

Concerning the relationship between age and hemorrhages, a higher frequency of occurrence was shown in younger victims (Table 1). This higher frequency of occurrence among younger victims was confirmed by a logistic regression test (a highly significant association, $p < 0.001$, Fig. 3).

Chi-square testing did not prove a significant association between the occurrence of Simon's hemorrhages in cases of hanging and the victims' sex ($p = 0.448$).

Discussion

In 1968, Axel Simon (1,2) described hemorrhages into the anterior aspect of the intervertebral disks in the lumbar region of the spine on a series of 64 cases of hanging (53 of them showed the typical hemorrhages). This observation was confirmed in

TABLE 1—Association between the occurrence of hemorrhages into the anterior aspect of the intervertebral disks and the victim's age—absolute frequencies.

	Age			Total
	≤30	31–50	≥51	
Simon's bleedings				
Free suspension				
Presence	14	26	12	52
Absence	5	12	43	60
Total				112
Incomplete suspension				
Presence	3	8	2	13
Absence	2	20	31	53
Total				66

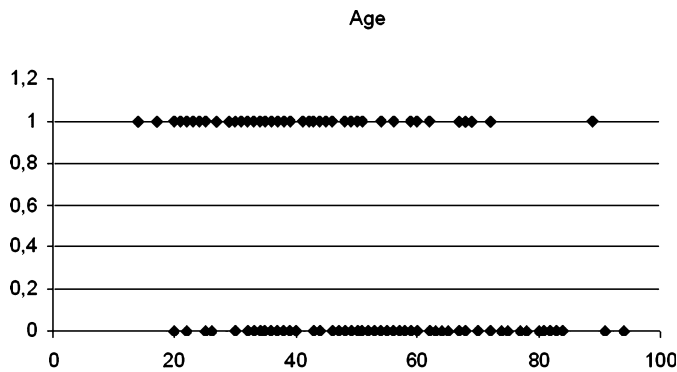


FIG. 3—Association between the occurrence of hemorrhages into the anterior aspect of the intervertebral disks and the victim's age. A higher frequency of occurrence in young victims was confirmed by a logistic regression test (highly significant association, $p < 0.001$).

subsequent autopsy studies: Geserick et al. (10,11) in 29.2% of 840 autopsy cases retrospectively evaluated; Kleiber et al. (12) in 47% of 222 cases of hanging; and Saternus (13) in 56% of 32 cases of hanging. There were no hemorrhages into the anterior aspect of the intervertebral disks in the postmortem experiments of hanging (14).

The frequency of occurrence of Simon's hemorrhages in our group did not significantly differ from previous studies (10–13); however, it was lower than in Simon's first published articles (1,2). The discrepancy of the results could be explained by methodical approach and methodical factors.

Simon assumed that the origin of hemorrhages in cases of hanging is connected with overexpansion of the spine because of free suspension of the body (1,2). His original idea was confirmed by results of our study as well. In cases with free suspension of the victim, the occurrence of hemorrhages was significantly more frequent than in cases with incomplete suspension. However, hemorrhages also occur in cases of hanging with incomplete suspension (15), but with a lower relative frequency. It is obvious that free suspension of the body plays an important role in the occurrence of these hemorrhages.

From the results, it is apparent that the occurrence of Simon's hemorrhages is influenced by the advancement of degenerative changes in the spine. Degenerative changes in the lumbosacral part of the spinal column, for instance, osteophytes or deformations of vertebral bodies, lead to increased rigidity of the spine as a whole and limit the possibility of hyperextension of the spine and the origination of hemorrhages. This fact also indirectly supports Simon's original idea of the pathogenesis of the origination of these hemorrhages (1). We carried out autopsies on a married couple who hanged themselves at the same time on a chandelier in their bedroom (free suspension); in the case of the woman, Simon's sign was very well recognizable, but in case of the man, it was missing completely. The man suffered from an osteodegenerative disease of the lumbar spine. The occurrence of Simon's bleedings is also significantly lower in rather elderly individuals, which is most probably again connected with the advancement of osteodegenerative changes in the spine and increased rigidity of the spine.

Simon's bleedings in cases of hanging most likely occur because of agonal convulsions and forceful movements in the lumbosacral part of the spinal column. Agonal convulsions in suicidal hangings begin shortly after the onset of hanging (16,17) and are followed by decortication rigidity with extension of the trunk and lower limbs (16). Such specific movements result in strong lateral stimulation of the lumbar spine and consequent ruptures of the vessels

originating from the spinal tract of the lumbar artery. An additional important factor for the appearance of these bleedings in hanging is also traction of the body as a result of gravity (13).

The occurrence of Simon's sign in other nonnatural forms of death is rare and is most often connected with hyperextensive violence against the spine (8,9). This fact was also observable in our control group, where in all cases with Simon's sign, the spine was directly or indirectly exposed to a certain form of hyperextensive violence. In these cases, Simon's bleedings occur more often in the thoracic spine area or in the area of transition between the thoracic and lumbar spine rather than in the lumbar spine area, and they are generally less apparent. The occurrence was also described in the cervical spine area, in a case of positional asphyxia (18).

Simon's sign could be of great importance in considering traffic accidents where the presence and localization of hemorrhages can contribute to reconstructing the mechanics of how the accident, or injury, occurred. In these cases, Simon's sign points out hyperextensive trauma of the spine. In cases of fatal hypothermia, the occurrence of Simon's hemorrhages could be connected with intensive shivering and forceful movements of the lumbar spine. Intensive movements of the trunk and agonal convulsions could also be the mechanisms by which Simon's bleedings appear in cases of drowning.

Conclusion

- Simon's sign can be evaluated as a valid diagnostic autopsy sign of premortem hanging as well as the proof of premortem hanging.
- Simon's sign can be considered as an objective vital finding, which is not absolutely specific for hanging. The absence of hemorrhages does not exclude death by hanging.
- Simon's hemorrhages have diagnostic significance in cases of hanging where there is a minimum amount of findings on the cervical organs; in such situations, the presence of Simon's sign has high diagnostic value.
- Simon's sign in cases of hanging is more frequent in rather young individuals, in cases with free body suspension, and in individuals with minimal degenerative changes in the lumbosacral part of the spinal column.
- Simon's bleedings in cases of hanging most likely occur because of a combination of agonal convulsions and traction of the body as a result of gravity.
- Simon's sign in blunt trauma fatalities is most often connected with direct or indirect hyperextensive violence against the spinal column.
- Simon's bleedings in cases of natural death are exceedingly rare.

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