# Agonal Sequences in 14 Filmed Hangings With Comments on the Role of the Type of Suspension, Ischemic Habituation, and Ethanol Intoxication on the Timing of Agonal Responses

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**Abstract:** The Working Group on Human Asphyxia has analyzed 14 filmed hangings: 9 autoerotic accidents, 4 suicides, and 1 homicide. The following sequence of agonal responses was observed: rapid loss of consciousness in 10 ± 3 seconds, mild generalized convulsions in 14 ± 3 seconds, decerebrate rigidity in 19 ± 5 seconds, beginning of deep rhythmic abdominal respiratory movements in 19 ± 5 seconds, decorticate rigidity in 38 ± 15 seconds, loss of muscle tone in 1 minute 17 seconds ± 25 seconds, end of deep abdominal respiratory movements in 1 minute 51 seconds ± 30 seconds, and last muscle movement in 4 minutes 12 seconds ± 2 minutes 29 seconds. The type of suspension and ethanol intoxication does not seem to influence the timing of the agonal responses, whereas ischemic habituation in autoerotic practitioner might decelerate the late responses to hanging.

**Key Words:** hanging, asphyxia, video recording, pathophysiology, human, ethanol

(*Am J Forensic Med Pathol* 2010;XX: 000–000)

Hanging is a form of asphyxia characterized by a constriction of the neck by a ligature tightened by the gravitational weight of the body or part of the body.[1] Death has traditionally been attributed to 3 possible mechanisms: closure of the blood vessels of the neck, compression of the air passages, and vagal stimulation by pressure on the baroreceptors in the carotid sinuses and the carotid body.[2–4] This explanation of the mechanism of death is largely based on old writings and experimentation from the end of the 19th century and beginning of the 20th.[5] Apart from a few animal studies that gave very limited information on the pathophysiology of hanging in human,[6] there was slight new development on this issue until the recent studies on filmed hangings by the Working Group on Human Asphyxia.[7,8]

In a series of 8 filmed hanging, it was demonstrated that all cases demonstrated deep rhythmic abdominal respiratory movements.[8] These respiratory movements were not only visualized but were also clearly audible. This fact strongly challenges the theory of the obstruction of the air passage as a mechanism of death in hanging. It could be argued, however, that hearing breath sounds does not eliminate the possibility of a partial airway obstruction. Although it is now clear that tracheal occlusion is not complete in some hangings, it would be premature to totally exclude some implication of partial airways obstruction in the mechanism of death in all hangings.

Besides the presence of clear audible respiration in some cases, the study of filmed hangings has also documented the sequence of agonal responses in these deaths[8]: a rapid loss of consciousness after 8 to 18 seconds, closely followed by convulsions at 10 to 19 seconds, then a complex pattern of decerebrate rigidity and decorticate rigidity, a loss of muscle tone after 1 minute 38 seconds to 2 minute 15 seconds, and isolated body movements until the last movements between 1 minute 2 seconds and 7 minute 31 seconds. The description of this agonal sequence constitutes a major advance in the understanding of the pathophysiology of human hanging. Nevertheless, additional cases are needed before we can pretend to fully grasp the agonic sequence in hanging deaths and appreciate its variability. This fact was recently emphasized by the report of an unusual case of hanging without decerebrate or decorticate rigidity.[9] In this film of a hanging with complete suspension of the body, a 52-year-old man stepped off a stool and the movement of the body stepping off the stool created a rotary movement around the ceiling's ring. Apart from the rolling around the ceiling's ring, the body stayed motionless for the duration of the movie, without any evidence of decerebrate or decorticate rigidity. A possible elucidation of this singularity was proposed: the particular revolving movement of the body around the ceiling's ring created a vestibular stimulation that interfered with the development of the decerebrate rigidity.[9]

Here we present 5 additional filmed hangings, raising the number of filmed hangings studied to 14.

## MATERIALS AND METHODS

For each video, we evaluated the time frame of the following body responses: loss of consciousness, convulsions, decorticate rigidity, decerebrate rigidity, loss of muscle tone, last muscle movement, and respiratory responses. All recording were evaluated jointly by at least 2 judges, one of the judges having seen all the videos.

## RESULTS

The Working Group on Human Asphyxia has compiled and analyzed 14 filmed hangings: 9 autoerotic accidents, 4 suicides, and 1 homicide. All victims were adults. Most were white males, with the exception of an Asiatic male (case 9) and a white female (case 11). A brief description of each case and the observed agonal sequence are presented in Table 1. The time to the various responses is assessed considering time zero to represent the onset of the final hanging. In case 14, however, the victim tied the ligature very tightly 2 seconds before the hanging and in this case, the time estimates were done considering time 0 to be the tightening of the ligature.

Manuscript received June 7, 2010; accepted June 22, 2010.

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ISSN: 0195-7910/10/0000-0001
DOI: 10.1097/PAF.0b013e3181efba3a

**TABLE 1.** Agonal Responses in 14 Filmed Hangings

| No | Circumstances | Type of Suspension | Toxicology | Movement Responses | | | | | | | Respiratory Responses (Very Deep Respiratory Attempt) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Loss of Consciousness | Convulsions | Decerebrate Rigidity | Decorticate Rigidity 1 | Decorticate Rigidity 2 (and 3) | Loss of Muscle Tone | Last Muscle Movement | Start | End |
| 1 | Suicide | Incomplete; Feet on the ground | No intoxication | 13 s | 15 s | 19 s | 21 s | 1 min 11 s | 1 min 38 s | 4 min 10 s | 20 s | 2 min 00 s |
| 2 | Autoerotic | Incomplete; feet on the ground | No intoxication | Nd | 14 s | 19 s | 1 min 08 s | 1 min 32 s | 2 min 15 s | 2 min 47 s | 21 s | 2 min 03 s |
| 3 | Autoerotic | Complete | No intoxication | 18 s | 19 s | 21 s | 1 min 00 s | 1 min 04 s | 2 min 04 s | 3 min 01 s | 22 s | 2 min 04 s |
| 4* | Suicide | Incomplete; kneeling on the ground | No intoxication | Nd | 18 s | Nd | Nd | Nd | Nd | Nd | 24 s | Nd |
| 5 | Autoerotic | Incomplete; almost completely lying down in a prone position | Nd | 10 s | 13 s | 1 min 19 s | 59 s | — | 1 min 52 s | 7 min 31 s | 13 s | 2 min 05 s |
| 6 | Autoerotic | Incomplete; feet on the ground | Nd | 8 s | 11 s | 31 s | 33 s | — | — | 1 min 02 s | 19 s | 1 min 02 s |
| 7 | Autoerotic | Incomplete, feet on the ground | Nd | 10 s | 10 s | 11 s | 26 s | 34 s | Nd† | Nd† | 13 s | Nd† |
| 8 | Autoerotic | Incomplete; feet on the ground | No intoxication | 12 s | 14 s | 20 s | 31 s | — | Nd† | Nd† | 16 s | Nd† |
| 9‡ | Suicide | Complete | Ethanol 10 mg/100 mL in the femoral blood | Nd | Nd | — | — | — | — | — | Nd | Nd |
| 10 | Autoerotic | Seems incomplete; feet probably on the ground | No intoxication | 8 s | 12 s | 20 s | 24 s | 39 s (and 1 min 55 s) | 2 min 45 s | 7 min 35 s | 16 s | 2 min 37 s |
| 11 | Suicide | Incomplete; feet on the ground | No intoxication | 8 s | 11 s | Nd§ | 43 s | 57 s | 1 min 25 s | 3 min 15 s | 32 s | 1 min 15 s |
| 12¶ | Homicide‖ | Incomplete, feet on the ground | Ethanol 156 mg/100 mL in the femoral blood**; THC 6.5 ng/mL in the femoral blood | 9 s | Nd | 16 s | Nd | Nd | Nd | Nd | Nd | Nd |
| 13 | Autoerotic | Complete | Nd | 10 s | 15 s | 22 s | 39 s | 50 s (and 57 s) | 1 min 53 s | Nd | 17 s | 1 min 43 s |
| 14 | Autoerotic | Incomplete, feet on the ground | Nd | 8 s | 11 s | 14 s | 35 s | 45 s (and 53 s) | 1 min 42 s | Nd† | Nd†† | Nd†† |

*The film obtained from a surveillance camera was not of optimal quality and several responses are difficult to assess.

†A few copies of films have been cut to early to allow evaluation of the late responses.

‡There was no decerebrate or decorticate rigidities in this case (the case was published as a case report,[9]).

§At the beginning of the hanging, both arms are bent with the fingers slide between the ligature and the neck. The decerebrate rigidity is not seen probably because of this restriction limb movement. Later, the right fingers slip from the ligature and decorticate rigidity is seen.

¶Several body responses are difficult to assess because the victim is in the shadow.

‖An erotic asphyxia practitioner asked for the help of his spouse in his practice. He was hanging himself and indicating her when to stop the process. On a filmed hanging, she was seen to ignore his sign to stop the hanging and let him die.

**The victim is seen consuming several beers at the beginning of the film, before the hanging.

††The respiratory attempt are seen but the timing was difficult to assess because of the angle of the camera.

Nd indicates no data; —, not observed.

Loss of consciousness was largely assessed by a close examination of the victim's face, voluntary movements, and body tonus. In 3 cases (cases 2, 4, and 9), loss of consciousness was not possible to evaluate: in case 2, the victim's face was masked with underwear; in case 4, image quality from the surveillance camera was not optimal enough to estimate this issue adequately; in case 9, the onset of the loss of consciousness and of convulsions was not clearly identifiable. In all the other cases, a rapid loss of consciousness was observed in 8 to 18 seconds (average, 10 ± 3 seconds). The loss of consciousness was closely followed by mild generalized, tonic-clonic convulsions in 10 to 19 seconds (average, 14 ± 3 seconds).

Decerebrate rigidity then followed. This postural attitude of marked extensor rigidity is characterized by a full extension of the upper and lower limbs, with extension of the hips and knees, adduction of the legs, internal rotation of the shoulders, extension of the elbows, hyperpronation of the distal parts of the upper limbs with finger extension at the metacarpophalangeal joints, and flexion at the interphalangeal joints. This extensor posturing was observed in 11 seconds to 1 minute 19 seconds (average, 25 ± 19 seconds). If we exclude the only case in which decorticate rigidity preceded decerebrate rigidity (case 5), the posturing occurred in an average of 19 ± 5 seconds.

After the decerebrate rigidity, a decorticate rigidity occurred: this postural attitude is characterized by marked extensor rigidity of the legs, identical to the one observed in decerebrate rigidity, but combined with rigidity of the flexors of the arms: the arms are flexed and bent on the chest, with the hands clenched into fists. A first phase of decorticate rigidity was relatively sudden and quick. It was generally followed by a second and sometimes a third phases of decorticate rigidity, these subsequent ones developing more slowly and being more sustained. The first decorticate rigidity appeared in 21 seconds to 1 minute 8 seconds (average, 40 ± 16 seconds). If we exclude case 5, the posturing first begins in an average of 38 ± 15 seconds.

Between 1 minute 38 seconds and 2 minutes 45 seconds (average, 1 minute 17 seconds ± 25 seconds), the body lost its muscle tone and became progressively flaccid. Subsequently, isolated body movements were observed from time to time, the last one occurring between 1 minute 2 seconds and 7 minutes 35 seconds (average, 4 minutes 12 seconds ± 2 minutes 29 seconds).

As for the respiratory responses, deep rhythmic abdominal respiratory movements were seen These respiratory movements, with rhythmic rocking of the body by the contraction of the diaphragm, started between 13 and 32 seconds (average, 19 ± 5 seconds) and stopped between 1 minute 2 seconds and 2 minutes 37 seconds (average, 1 minute 51 seconds ± 30 seconds). It is worth emphasizing that these respiratory movements were not only seen but also heard when sound was available, confirming the passage of air in the airways despite the hanging process.

**TABLE 2.** Agonal Sequence in Hanging

| | Average Time |
|---|---|
| Loss of consciousness | 10 ± 3 s |
| Convulsions | 14 ± 3 s |
| Decerebrate rigidity | 19 ± 5 s |
| Stat of deep rhythmic abdominal respiratory movements | 19 ± 5 s |
| Decorticate rigidity | 38 ± 15 s |
| Loss of muscle tone | 1 min 17 s ± 25 s |
| End of deep rhythmic abdominal respiratory movements | 1 min 51 s ± 30 s |
| Last muscle movement | 4 min 12 s ± 2 min 29 s |

**TABLE 3.** Timing of the Agonal Responses: Comparison of Autoerotic Hangings Versus Nonautoerotic Hangings

| | Autoerotic Hangings | Nonautoerotic Hangings |
|---|---|---|
| Loss of consciousness | 11 ± 3 s | 10 ± 3 s |
| Convulsions | 13 ± 3 s | 15 ± 4 s |
| Decerebrate rigidity | 20 ± 6 s | 18 ± 2 s |
| Stat of deep rhythmic abdominal respiratory movements | 17 ± 3 s* | 25 ± 6 s* |
| Decorticate rigidity | 40 ± 16 s | 32 ± 16 s |
| Loss of muscle tone | 2 min 5 s ± 23 s* | 1 min 31 s ± 9 s* |
| End of deep rhythmic abdominal respiratory movements | 1 min 56 s ± 31 s | 1 min 38 s ± 32 s |
| Last muscle movement | 4 min 23 s ± 2 min 59 s | 3 min 42 s ± 39 s |

*Comparisons between both groups using Mann-Whitney $U$ were significant at $P < 0.05$.

## DISCUSSION

Despite the great diversity of hangings included in this study, the similarity between most cases is striking. The agonic sequence observed in hanging is summarized in Table 2. This study provides a comprehensive portrait of the pathophysiology of human hanging.

### The Role of the Type of Suspension on the Timing of Agonal Responses

A comparison of time delay for agonal responses in complete suspension (cases 3 and 13) and incomplete suspension (cases 1–2, 4–8, 10–12, 14) do not reveal impressive differences. However, the small number of cases in the complete suspension group precludes statistical analyses. These preliminary results suggest that the type of suspension may not be an important factor in the timing of agonal responses and therefore in the time to irreversible damage and death. Further cases are needed to assess the validity of this observation.

In the present study, most cases of incomplete hangings were in an upright position with feet on the ground, with only 1 case of incomplete hanging in a kneeling position (case 4) and one case of incomplete hanging lying down (case 5). By comparing the timing of responses in these cases, there is no evidence that the position of the incomplete suspension interferes with the time delay. Further cases are needed to assess the validity of this preliminary statement. It should be pointed out, however that the only case with an inversion of the sequence of decerebrate and decorticate rigidity is the case in a lying down position (case 5). It is unknown at this time if this position plays a role in this inversion of the sequence.

### The Role of Ischemic Habituation on the Timing of Agonal Responses

Considering that autoerotic practitioners might develop over time a certain ischemic habituation, it is theoretically possible that these cases present a deceleration of the sequence. In contrast, as they often play for a longer period with the hanging process before the final hanging, it could be argue that on the contrary, their hanging sequence will be accelerated. A comparison of the timing of agonal responses in autoerotic hangings versus nonautoerotic hangings is presented in Table 3. Overall, the time delays for the early responses to hanging seem to be relatively similar between both groups, with the exception of an accelerated start of deep abdominal respiratory movements in the autoerotic practitioners. As for the late responses to hanging, they seem to be

decelerated in autoerotic practitioners. Statistical analysis confirmed a significant difference between both groups for 2 variables: the start of the deep abdominal respiratory abdominal movement occurred significantly faster in autoerotic practitioner whereas the loss of muscle tone was significantly delayed. Further research is needed to determine whether and under which circumstances ischemic habituation plays a role on the agonal sequences.

## The Role of Ethanol Intoxication on the Timing of Agonal Responses

An expert-witness recently stated that a victim intoxicated by ethanol will die more quickly from strangulation than a sober victim, alleging that ethanol is a respiratory depressant. We could not find any animal or human studies to support or refute this theory. In the present study, 1 victim was intoxicated with ethanol (case 12). This intoxication state does not seem to have accelerated the timing of agonal responses. It would be interesting to further evaluate the effect of ethanol on the timing of agonal responses to hanging on the animal model of hanging previously proposed by Boghossian et al.[6]

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