

Hanging in There. Living beyond Hanging: A Retrospective Review of the Prognostic Factors from a Regional Trauma Center

Saptarshi Biswas¹, Heather Rhodes², Kirklen Petersen³, Kyle Schwarz⁴, Gaukhar Amandossova⁵

ABSTRACT

Background: A common cause of suicide in the United States is hanging, which is increasing in incidence. Patients with near-hanging injuries survive long enough to present to the emergency department for resuscitative care. Identifying prognostic factors that can predict survival is needed to improve emergency management in this patient population.

Materials and methods: A retrospective review of all patients diagnosed with an attempted suicide by hanging that presented to a regional level 2 trauma center was studied, inclusive years January 2013 to December 2017. The patients who died upon arrival were excluded. The data collected for comparison included demographic with prognostic characteristics, trauma center admission vitals, type and frequency of injuries, and near-hanging outcomes.

Results: Several statistically significant findings were presented. Associations between systolic blood pressure (BP) upon admission of <90 Hg in patients <65 years of age and survival were statistically significant (Fisher's exact test, $p = 0.005$). The association between Glasgow coma scale (GCS) category and survival was statistically significant (Fisher's exact test, $p = 0.012$). Further, there was a weak positive association between the GCS category on admission vitals and survival ($F = 0.554$, $p = 0.006$). Associations between cervical spine injury with fracture and survival were significant (Fisher's exact test, $p = 0.024$). A strong negative relationship was found between cerebral anoxia and survival ($F = -0.772$, $p = 0.001$). The association between cerebral injury and survival was statistically significant (Fisher's exact test, $p = 0.002$). Finally, a strong negative relationship was found between pulmonary edema and survival ($F = -0.592$, $p = 0.004$).

Conclusion: Independent risk factors for poor outcomes in near-hanging trauma were identified. These factors include relationships between systolic BP, GCS categories, admission vitals, cervical spine injuries with fracture, cerebral anoxia, cerebral injury, and pulmonary edema with survival.

Keywords: Hanging, Near-hanging, Trauma.

RESUMEN

Fondo: Una causa común de suicidio en los Estados Unidos es la horca, que está aumentando en incidencia. Los pacientes con lesiones cercanas a la horca sobreviven el tiempo suficiente para presentar al departamento de emergencias para recibir cuidados reanimados. Es necesario identificar los factores de pronóstico que pueden predecir la supervivencia para mejorar el manejo de emergencias en esta población de pacientes.

Métodos: Se estudió una revisión retrospectiva de todos los pacientes diagnosticados con un intento de suicidio por ahorcamiento que se presentó a un centro de trauma de nivel 2 regional, años inclusivos de enero de 2013 a diciembre de 2017. Los pacientes que murieron a su llegada fueron excluidos. Los datos recopilados para la comparación incluyeron la demografía con características de pronóstico, los signos vitales de admisión al centro de trauma, el tipo y la frecuencia de las lesiones, y los resultados casi pendientes.

Resultados: Se presentaron varios hallazgos estadísticamente significativos. Las asociaciones entre la presión arterial sistólica (BP) al ingresar <90 Hg en pacientes <65 años de edad y supervivencia fueron estadísticamente significativas (prueba exacta de Fisher, $p = 0.005$). La asociación entre la categoría de GCS y la supervivencia fue estadísticamente significativa ((prueba exacta de Fisher, $p = 0.012$). Además, hubo una débil asociación positiva entre la categoría GCS sobre los signos vitales de admisión y la supervivencia ($F = 0.554$, $p = 0.006$). Las asociaciones entre la lesión de la columna cervical con fractura y supervivencia fueron significativas (prueba exacta de Fisher, $p = 0.024$). Se encontró una fuerte relación negativa entre la anoxia cerebral y la supervivencia ($F = -0.772$, $p = 0.001$). La asociación entre la lesión cerebral y la supervivencia fue estadísticamente significativa (prueba exacta de Fisher, $p = 0.002$). Por último, se encontró una fuerte relación negativa entre el edema pulmonar y la supervivencia ($F = -0.592$, $p = 0.004$).

Conclusiones: Se identificaron factores de riesgo independientes para obtener resultados deficientes en traumas casi ahorcados. Estos factores incluyen relaciones entre la presión arterial sistólica, las categorías de GCS, los signos vitales de admisión, las lesiones de la columna cervical con fractura, la anoxia cerebral, la lesión cerebral y el edema pulmonar con supervivencia.

Palabras clave: Colgado, Casi Colgado, Trauma.

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INTRODUCTION

Hanging entails suspension by the neck often resulting in strangulation. It can be divided broadly into complete or incomplete. It is said to be complete when the whole body hangs

¹Department of Trauma, General Surgery and Surgical Critical Care, Grand Strand Medical Center, Myrtle Beach, South Carolina, USA

²Department of Trauma, Grand Strand Medical Center, Myrtle Beach, South Carolina, USA

off the ground, and the entire weight of the victim is suspended at the neck. Incomplete hangings imply that some part of the body is touching the ground and that the neck does not fully support the victim's weight. Judicial hanging is defined when the drop is at least as long as the victim's height and the hanging is complete. The death mechanism in judicial hanging is often attributed to decapitation, with the head's distraction from the neck and torso, occasionally with fracture of the upper cervical spine (traumatic spondylolysis of C2 in the classic hangman fracture), and transection of the spinal cord.^{1,2} Death can also occur from a range of head and neck injuries, particularly compression or rupture of the vertebral and carotid arteries leading to cerebral ischemia.²

Near hanging refers to patients who survive a hanging injury long enough to reach the hospital. This suicidal hanging usually differs from judicial hanging in many ways. Unlike judicial hanging, suicidal hanging is rarely associated with cervical fractures, which are as low as 5% of all cases.³ Furthermore, death is often attributed to cerebral ischemia resulting from disruption of cerebral blood flow related to the noose around the neck. Cardiac arrest as a result of autonomic hyperactivity from stimulation of vasoactive centers in the great vessels; protrusion of the tongue and epiglottis causing airway compromise; jugular venous occlusion, carotid artery occlusion by neck closure, and vertebral artery occlusion by spinal injuries all contribute in a cumulative way to acute cerebral hypoxia.^{2,4-6}

Hanging is the second most common cause of suicide in the United States after firearms, claiming over 10,000 lives each year, and its incidence is increasing.^{7,8} Despite the frequent occurrence of suicidal attempts and potential near-hanging injuries, few studies have evaluated the prognostic factors that can predict survival following a near-hanging experience. This study aims to evaluate independent risk factors for poor outcomes in hopes of improving the emergency management of near-hanging victims.

MATERIALS AND METHODS

A retrospective cross-sectional study of all patients diagnosed with an attempted suicide by hanging and were transported by emergency medical services to a regional level 2 trauma center in Pennsylvania, inclusive years January 2013 to December 2017. The patients who died upon arrival were excluded. This study received support from Lecom the Lake Erie Osteopathic College of Medicine in Erie, PA. The Institutional Review Board was granted by Allegheny Health Network, which facilitated manually extracted data from medical record review and ambulance reports. The data were assessed for normality of continuous variables using the Shapiro–Wilk test. Continuous normally distributed variables were reported as mean and the standard deviation; non-normally distributed variables were reported as median with interquartile range (IQR). Categorical variables were presented as counts and percentages. The independent sample *t*-test or Mann–Whitney *U*-test was used, which was appropriate to compare continuous variables. The Chi-squared test or Fisher's exact test was used to compare categorical variables. The phi coefficient (*F*) was given as a measure of the association between two categorical variables. A value of $p < 0.05$, on two-tailed testing, was considered statistically significant. Statistical analyzes were performed using IBM-SPSS Statistics, version 24.0 (IBM Corp., Armonk, NY). Demographics with prognostic characteristics included age, gender, race, hanging method, type of ligature used, and contact with the ground. The patients were grouped by trauma center admission vitals, type and frequency of injuries, and outcomes of near hangings (Tables 1 to 4).

³University of South Carolina School of Medicine, Columbia, South Carolina, USA

^{4,5}Forbes Hospital, Allegheny Health Network, Pennsylvania, USA

Corresponding Author: Saptarshi Biswas, Department of Trauma, General Surgery and Surgical Critical Care, Grand Strand Medical Center, Myrtle Beach, South Carolina, USA, e-mail: Saptarshi.Biswas@hcahealthcare.com

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Table 1: Demography with prognostic characteristics ($n = 25$)

Variable	Result
Age [median (range)]	36 (15–49)
Gender, <i>N</i> (%)	
Male	16 (64%)
Female	9 (36%)
Race, <i>N</i> (%)	
Caucasian	21 (84%)
African-American	2 (8%)
Hispanic	1 (4%)
Asian	0
Hanging method, <i>n</i> (%)	
Incomplete	8 (32%)
Complete	17 (68%)
Type of ligature used, <i>n</i> (%)	
Belt	5 (20%)
Clothing	
Pants	1 (4%)
T-shirt	1 (4%)
Scarf	1 (4%)
Shoe lace	1 (4%)
Cord (includes extension cord, electric cord, power cord and unspecified type of cord)	5 (20%)
Sheet (includes bed sheet or unspecified type of sheet)	2 (8%)
Towel	2 (8%)
Rope	6 (24%)
Ratchet strap	1 (4%)
Contact on the ground	8 (32%)

RESULTS

A total of 25 patients were admitted to an adult level 2 trauma center with near-hanging injuries, inclusive years January 2013 and December 2017. The association between systolic blood pressure (BP) upon admission of <90 Hg in patients <65 years of age and survival was statistically significant (Fisher's exact test, $p = 0.005$). The association between GCS category and survival was statistically significant (Fisher's exact test, $p = 0.012$). Of the 16 patients in the category of GCS 13–15, 93.8% survived. Within the GCS category of 3–8, 4 of the 9 patients survived. There was a weak positive association between the GCS category on admission vitals and survival ($F = 0.554$, $p = 0.006$). A cervical spine injury with fracture was diagnosed in 2 of the 23 patients (8.7%); both died.

Table 2: Trauma center admission vitals (*n* = 25)

Variable	Result
Systolic findings at admission of <90 Hg in patients <65 years of age, <i>n</i> (%)	5 (20%)
Glasgow coma score (GCS), <i>n</i> (%)	
GCS 13–15	16 (64%)
GCS 9–12	0
GCS 3–8	9 (36%)
GCS on presentation for those who survived (<i>n</i> = 19), <i>n</i> (%)	
GCS 13–15	15 (78.9%)
GCS 9–12	0
GCS 3–8	4 (21.1%)
GCS on presentation for those who died (<i>n</i> = 6), <i>n</i> (%)	
GCS 13–15	0
GCS 9–12	0
GCS 3–8	6 (100%)
SpO ₂ on arrival, <i>n</i> (%)	
Mean ± SD	92.0 ± 20.9
Median (IQR)	98 (3.0)
Range	0–100

Table 3: Type and frequency of injuries (*n* = 23*)

Variable	Result
Injuries to neck structures, <i>n</i> (%)	
Laryngeal fracture/edema	1 (4.3%)
Cervical spine injury/fracture	2 (8.7%)
Tracheal injury	0
Pharyngeal injury	0
Carotid injury	0
Injuries to the pulmonary system, <i>n</i> (%)	
Pulmonary edema	5 (21.7%)
Pulmonary infection/aspiration pneumonia	3 (13%)
Acute respiratory distress syndrome	0
Pneumothorax	1 (4.3%)
Injuries to the brain	
Cerebral anoxia	6 (26.1%)
Cerebral injury including ischemic stroke/cerebral edema	3 (13%)
Status epilepticus during hospital stay, <i>n</i> (%)	0
Multiple organ failure during hospital stay, <i>n</i> (%)	2 (8.7%)

*Only 23 patients had data available for analysis. On patient (ID #2) was pronounced dead on arrival and one patient (ID #12) was classified as a mortality and had 0 days in the hospital

The association between cervical spine injury with fracture and survival was statistically significant (Fisher's exact test, $p = 0.024$). Cerebral anoxia was diagnosed in 6 of the 23 patients. Of those with diagnosed cerebral anoxia, 4 of the 6 patients (66.7%) diagnosed dead. Extracted data from injuries related to incomplete hanging showed 3 deaths out of 6 total patients. Further, there were 3 out of 6 related deaths to complete hanging. A strong negative relationship was found between cerebral anoxia and survival ($F = -0.772$, $p = 0.001$). Cerebral injury, including ischemic stroke/cerebral edema, was diagnosed in 3 of the 23 patients, who later died. The association between cerebral injury and survival was

Table 4: Outcomes of near hanging (*n* = 25)

Variable	Result
Outcomes of near hanging, <i>n</i> (%)	
Died	6 (24%)
Survived	19 (76%)
ICU length of stay (<i>n</i> = 24) ¹	
Mean ± SD	1.9 ± 3.2
Median days (IQR)	0 (3.0)
Range of days	0–14
Organ donor, <i>n</i> (%), (<i>n</i> = 6)	5 (83.3%)
Hospital length of stay, median days ¹	
Mean ± SD	4.0 ± 4.2
Median days (IQR)	3.5 (4.0)
Range of days	0–21
No disability (patient recovered), <i>n</i> (%) (<i>n</i> = 19) ²	17 (89.5%)
Temporary disability, <i>n</i> (%), (<i>n</i> = 19) ²	2 (10.5%)
Persistent vegetative state, <i>n</i> (%), (<i>n</i> = 19) ²	0
Neuropsychiatric sequelae (permanent neuro damage), <i>n</i> (%), (<i>n</i> = 19) ²	0
Follow-up period (months), (<i>n</i> = 19) ²	5 (26.3%)
Lost to follow-up, <i>n</i> (%), (<i>n</i> = 19) ²	14 (73.7%)

¹Data were available on 24 patients, as 1 patient was declared "dead on arrival."

²Data were available on 19 patients, as 6 patients died and follow-up was not applicable



Fig. 1: Cervical spine computed tomography findings: edema in the C5–C6 and C6–C7 interspinous space likely representing acute injury to the interspinous ligaments

statistically significant (Fisher's exact test, $p = 0.002$). Pulmonary edema was diagnosed in 5 of the 23 patients (21.7%). Pulmonary edema with death impacted three out of five patients (60%). Of the three patients who died of pulmonary edema, none made use of a rope for their attempted suicide; two patients had injuries related to complete hanging, and one patient was reported to have touched the ground. A strong negative relationship was found between pulmonary edema and survival ($F = -0.592$, $p = 0.004$).

In Figure 1, symmetric restricted diffusion involving the cortex, basal ganglia, and thalami bilaterally can be seen. There is increased T2 flair imaging in this region. Findings are compatible with history

of anoxic brain injury. In Figure 2, findings are suggestive of hypoxic brain injury as described with cerebral swelling and possible mild hypodensity at the deep gray nuclei. In Figure 3, there is edema in the C5-C6 and C6-C7 interspinous space likely representing acute injury to the interspinous ligaments.

DISCUSSION

On an average, 50% of hanging suicides are not fully suspended, and ligature points below head level are commonly used.⁸ Although the case fatality following an attempted suicide by hanging is around 70%, most (80–90%) of those who reach the hospital alive survive.⁸ The emergency management of near-hanging victims is crucial in that delayed deaths are mostly due to complications of hanging.^{8,9}

Autopsy studies have documented injuries resulting from hanging. Common injuries include thyroid cartilage/hyoid fractures, trachea laryngeal fractures, vertebral injuries, cervical vascular injuries, and anoxic brain injuries.^{6,10} In near-hanging patients who survived the hanging and were transported to the hospital alive, injuries often include pulmonary edema and bronchopneumonia, laryngeal injuries, hypoxic encephalopathy, pneumonia, cervical

vascular injuries, vertebral fractures, adult respiratory distress syndrome, and more.^{6,9,11,12}

Many studies have investigated the prognostic factors related to near-hanging injuries, yet a consensus has not been reached. Risk factors for poor outcomes include cardiac arrest at the hanging site, elevated diastolic BP, a low initial GCS, Acute Physiology and Chronic Health Evaluation II, 48-hour Sequential Organ Failure Assessment score, and an elevated blood glucose level.^{13–16} Other predictive measures of death and unsuccessful revival include loss of consciousness at the time of entry into the medical center, as well as complete suspension.¹⁷

This study has identified factors significantly associated with poor outcomes, including cervical spine injury with fracture; cerebral anoxia; cerebral injury, including ischemic stroke/cerebral edema; pulmonary edema; systolic BP upon admission of <90 Hg in patients <65 years of age; and GCS category. It is critical to recognize the prognostic factors in near-hanging patients to improve their emergency management, therefore improving overall survival.

The neurological deficits of near-hanging injuries are profound and include cervical spine injury and diffuse atonal injury.

Diffuse atonal atrophy from the sudden acceleration and deceleration common with hanging attempts can lead to loss of consciousness and death. Near hanging can often result in the rupture of the interspinous ligaments.

Other serious negative health outcomes include carotid artery dissection, stroke, seizures, cortical edema, and intracerebral hemorrhages.¹⁸ The strangulation causes an interruption of cerebral blood flow coupled with hypoxia from respiratory arrest, leading to loss of consciousness.¹⁸ Near hanging results in hypoxic/ischemic injuries to neurons due to oxygen and glucose deprivation.¹⁸ Neuronal death is followed by deficits in memory formation/cognition and executive function.¹⁸

Additionally, mechanical trauma to the cervical blood vessels and the airway can cause delayed neurological sequelae.¹⁸ Arterial dissections may occur, resulting in stroke.¹⁸ Trauma to the airway can cause delayed airway obstruction from tissue swelling, compounding the initial hypoxic insult.¹⁸

LIMITATIONS

The major limitations of the current study include retrospective methodology and small sample size. Data were obtained from

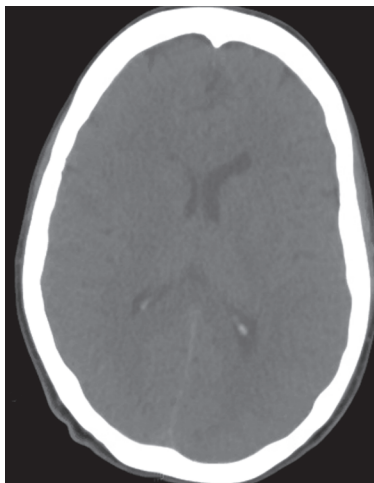
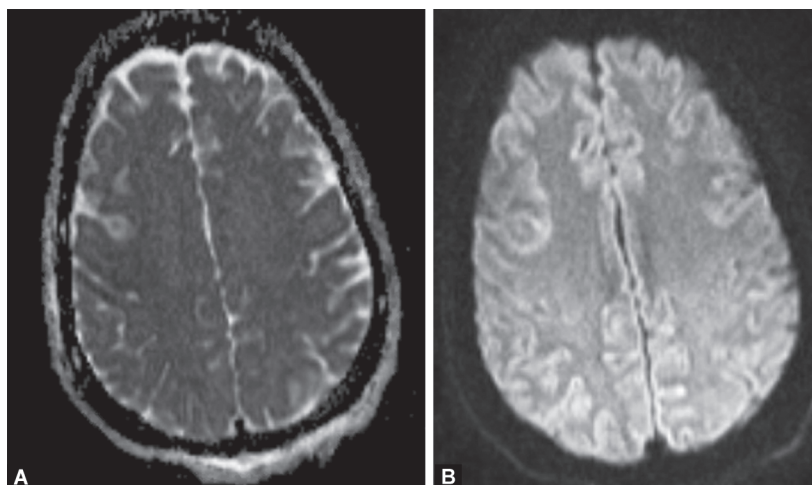


Fig. 2: Computed tomography of head impression: findings suggestive of hypoxic brain injury as described with cerebral swelling and possible mild hypodensity at the deep gray nuclei at the brain



Figs 3A and B: Magnetic resonance imaging of the brain: (A) Apparent diffusion coefficient map; (B) Diffusion findings: there is symmetric restricted diffusion involving the cortex, basal ganglia and thalami bilaterally. There is increased T2 flair imaging in this region. Findings are compatible with history of anoxic brain injury

medical record review and ambulance reports and, therefore, may be limited by documented data availability. The small sample size may undermine the internal and external validity of the study. Some potential confounding variables may not have been available for analysis. Data on important variables such as blood alcohol level and other drugs at the time of attempted suicide was not available. Finally, this study was carried out in a suburban level 2 adult trauma center, which provides services that may not be available in other hospital settings, thus lessening these study results' generalizability.

CONCLUSION

Independent risk factors for poor outcomes in near-hanging trauma were identified. Further larger studies are required to determine the epidemiology and prognostic implications associated with near-hanging injuries.

DISCLOSURES

In compliance with the ICMJE uniform disclosure form, all authors declared that they have received no financial support from any organizations that might have an interest in the submitted work, and there are no other relationships or activities that could appear to have influenced the submitted work.

DISCLAIMER

This research was supported (in whole or in part) by HCA Healthcare and/or an HCA Healthcare affiliated entity. The views expressed in this publication represent those of the authors and do not necessarily represent the official views of HCA or any of its affiliated entities.

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