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Brief Report

FACTORS ASSOCIATED WITH POOR OUTCOME IN PEDIATRIC NEAR-HANGING INJURIES

Stephanie La Count, MD,* Marlina E. Lovett, MD,*† Songzhu Zhao, MS,‡ David Kline, PHD,‡ Nicole F. O'Brien, MD,*† Mark W. Hall, MD,*† and Eric A. Sribnick, MD, PHD§||

*Department of Pediatrics, Nationwide Children's Hospital, The Ohio State University College of Medicine, Columbus, Ohio, †Division of Critical Care Medicine, Nationwide Children's Hospital, Columbus, Ohio, ‡Center for Biostatistics, The Ohio State University, Columbus, Ohio, §Division of Neurosurgery, Nationwide Children's Hospital, The Ohio State University, Columbus, Ohio, and ||Department of Neurosurgery, The Ohio State University, Columbus, Ohio

Corresponding Address: Eric Sribnick, MD, PHD, Nationwide Children's Hospital, 700 Children's Drive, Columbus, OH 43205

☐ **Abstract—Background: Hanging injury is the most common method of suicide among children 5 to 11 years of age and near-hangings commonly occur. Adult studies in near-hanging injury have shown that need for cardiopulmonary resuscitation, initial blood gas, and poor mental status are associated with poor prognosis. The literature for similar factors in children is lacking. Objectives: This retrospective, single-center study was performed to identify the clinical factors associated with neurologic outcome in children after near-hanging. Methods: Inclusion criteria included <18 years of age and a diagnosis of near-hanging or strangulation. All physician documentation was reviewed, and incidences of respiratory complications, seizure, and multiorgan failure were noted. Pediatric cerebral performance category score was based on information at discharge and was defined as favorable (score of 1–4) or unfavorable (score of 5–6). Comparisons were made between outcome groups and suspected clinical factors. Results: The median age was 11.5 years with a median initial Glasgow Coma Scale (GCS) score of 10. Of all patients, 25% had a prehospital cardiac arrest, and 51% were admitted to the intensive care unit. Patients with unfavorable outcomes had a lower initial pH (6.9 vs. 7.3) and initial GCS score (3T vs. 14). Patients with an unfavorable outcome had significantly higher rates of intensive care unit admission, respiratory complications, anoxic brain injury, and multiorgan failure. No patient who presented with an initial GCS score of 3T and prehospital cardiac arrest had a favorable neurologic outcome. Conclusions: This is the largest single-center study of children with near-hanging injury. An initial GCS score of 3T and prehospital cardiac arrest was uniformly associated with poor neurologic outcome. © 2019 Elsevier Inc. All rights reserved.**

☐ **Keywords—children; near-hanging; neurologic outcome**

INTRODUCTION

Over the last 2 decades, the annual suicide rate by suffocation has been steadily rising, increasing from 2.7 per 100,000 population from 1999 to 2007 to 3.7 per 100,000 population in 2008 to 2015 (1). Data from the National Violent Death Reporting System in 16 states from 2005 to 2014 show that 90.7% of asphyxial suicides involved hanging, translating to 22,931 lives (2). While most violent suicide attempts involve adults, a recent study noted that 10.5% of attempts involved children 10 to 19 years of age (3). Similarly, while the majority of hanging and near-hanging events involve adults, self-strangulation (hanging/suffocation) is the most common method of suicide among children, accounting for 78.2% of total suicide deaths of children 5 to 11 years of age from 1993 to 2012 in the United States (4).

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Hanging is defined as "death due to external pressure on the neck when a ligature is applied to the neck of a wholly or partly suspended individual (5)." The term "near-hanging" refers to individuals who survive the initial insult long enough to reach the hospital (5,6). A variety of factors have been proposed to guide clinicians in predicting neurologic outcomes in adults after near-hanging events, but similar work in pediatric patients is lacking (7–9). In adults, factors associated with a poor neurologic outcome after near-hanging include the use of cardiopulmonary resuscitation, initial arterial blood gas, and initial mental status (either an initial Glasgow Coma Scale [GCS] score of 3 at the time of discovery or comatose status at the time of arrival to the emergency department) (10,11). Similarly, in a small, single-center study of 41 children, those who were pulseless at the time of discovery were at high risk for death or severe disability (10). An important prognostic factor that has been described in adult studies is the duration of hanging, which is often not known in pediatric strangulation (12).

Given the paucity of data regarding clinical factors that can aid in neurologic prognostication of children after near-hanging injury, it is imperative to advance research in this area so that clinicians can better counsel families during this difficult time. Therefore, this large, single-center, retrospective study was performed to identify clinical factors that were associated with neurologic outcome in children after near-hanging.

MATERIALS AND METHODS

Patient Selection

Data for this study were obtained retrospectively from a state-mandated trauma database (Central Trauma Registry) that is maintained by dedicated data entry personnel under the supervision of nurse practitioners and physicians. Patients were treated at a level 1 pediatric trauma center between June 1992 and September 2015. This study was reviewed by the institutional review board. Informed consent was not required for admission into this study given its retrospective nature.

Patients were identified by description of injury in the trauma registry. Inclusion criteria included patients <18 years of age who were admitted with a diagnosis of near-hanging or strangulation. There were no exclusion criteria to this study.

Data Collection

Information extracted from the medical record included: patient demographics, mechanism of injury, medical history, vital signs at presentation, laboratory results at presentation, radiographic imaging, hospital course, and disposition. The initial blood gas data presented was obtained within 1 h of hospital presentation. Because of the evolving diagnostic criteria for the following diagnoses over the past 2 decades, the presence of complications, such as pulmonary complications (pulmonary edema or acute respiratory distress syndrome [ARDS]), seizure, pneumonia, and multiorgan failure were obtained from critical care or subspecialist documentation in the medical record during the hospital admission. The diagnosis of anoxic brain injury was obtained by reviewing all neuroimaging reports and interpretations. Within the institution, all neuroimaging is reviewed by a pediatric radiologist. Neurologic examination on the day of discharge was used to assign a Pediatric Cerebral Performance Category (PCPC) score for each patient, which is a validated measure of short-term neurologic outcome in children (13). The PCPC score ranges from 1 to 6; 1 = normal ("at age-appropriate level, school-age child attending regular school classroom"); 2 = mild disability ("conscious, alert, and able to interact at age-appropriate level; school-age child attending regular school classroom but grade perhaps not appropriate for age, possibility of mild neurologic deficit"); 3 = moderate disability ("conscious, sufficient cerebral function for age-appropriate independent activities of daily life; school-age child attending special education classroom or learning deficit present"); 4 = severe disability ("conscious; dependent on others for daily support because of impaired brain function"); 5 = coma or vegetative state ("any degree of coma without the presence of all brain death criteria; unawareness, even if awake in appearance, without interaction with environment; cerebral unresponsiveness and no evidence of cortex function [not aroused by verbal stimuli]; possibility of some reflexive response, spontaneous eye-opening, and sleep-wake cycles"); and 6 = brain death ("apnea, areflexia, and/or electroencephalographic silence") (13).

Statistical Analysis

Descriptive continuous data were reported as median with first and third quartiles, and categorical data were reported as percentage. The Fisher exact test was used for the comparison of categorical variables and the Wilcoxon test was used for the comparison of continuous variables. All statistical analyses were conducted using SAS software for Windows (version 9.4; SAS Institute Inc., Cary, NC). Statistical significance was defined as $p \leq 0.05$. To examine outcome, pediatric cerebral performance scores were grouped a priori into two categories: those with a more favorable neurologic outcome (PCPC score 1–4, from normal to severe disability) and those with an unfavorable neurologic outcome (PCPC score

5–6, those in a comatose/vegetative state or dead). Prehospital characteristics (limited to the presence or absence of prehospital cardiac arrest) and in-hospital characteristics of the study population were summarized for all subjects and also stratified by neurologic outcome group. To further evaluate the natural course of the disease process in children who died, characteristics were compared between children who had withdrawal of life support vs. those who did not.

RESULTS

Patient Demographics and Clinical Characteristics

Eighty-four patients met the inclusion criteria, and their demographics and clinical characteristics at presentation are shown in Table 1. Patients ranged from <1 to 17 years of age (median 11.5 years). After review of the medical record, a general cause of injury could be obtained in 79 cases (94%). Accidental ligature in an infant (1 month to 1 year of age) or toddler (1–3 years of age) was noted in 19 cases (24% of the patients with known causes of injury), and accidental ligature in an older child (>3 years of age) was noted in 9 cases (11.4%). Voluntary ligature without suicidal intent (e.g., "choking game") was noted in 8 cases (10.1% of patients with known causes of injury). However, most patients (43 cases) presented with a history suggesting voluntary ligature with suicidal ideation (54.4%).

Clinical findings among the cohort of patients are outlined in Table 2. Of the 84 total patients, 43 (51%) were initially admitted to the pediatric intensive care unit (PICU). The median PICU length of stay was 1 day (interquartile range 0–2 days), and the average hospital length of stay was 2 days (interquartile range 1–3 days). No cervical fractures or dislocations were discovered on review of radiographic imaging. There was evidence of anoxic brain injury in 16 patients (19.3% of the patient cohort).

To determine whether initial or prehospital characteristics correlated with outcome, patient outcome was measured by PCPC score, and patients were labeled as having either a favorable neurologic outcome (PCPC score of 1–4) or an unfavorable neurologic outcome (PCPC score of 5 or 6 [i.e., comatose state or death, respectively]). In our cohort, 90% of patients had either a PCPC score of 1 or 6 at the time of hospital discharge (Figure 1).

Data obtained either in the prehospital setting or at the time of admission were examined to determine if any observed findings correlated with patient outcome (Table 3). The unfavorable neurologic outcome group (PCPC score 5–6) was younger than those with a favorable neurologic outcome (8.5 vs. 12 years, $p = 0.02$). All patients in the unfavorable neurologic outcome group had a prehospital cardiac arrest compared with only 1 in the favorable neurologic outcome group ($p < 0.0001$). The unfavorable neurologic outcome group also had a lower pH on presentation (6.9 vs. 7.3, $p < 0.001$) as well as a lower initial GCS score (3T vs. 14, $p < 0.001$). All 20 patients with an unfavorable neurologic outcome (PCPC score 5–6) had both a prehospital cardiac arrest and an initial GCS score of 3T.

Of the 64 patients who ultimately had a favorable neurologic outcome (PCPC score 1–4) at the time of discharge, 6 had a GCS of 3T at initial hospital evaluation.

Table 1. Prehospital and Admission Patient Characteristics

Total, N	84
Male gender, n (%)	54 (64.3)
Prehospital cardiac arrest, n (%)	21 (25)
Age, y, median (Q1, Q3)	11.5 (3, 14)
Arterial blood gas pH,* median (Q1, Q3)	7.2 (7.0, 7.3)
Arterial blood gas CO2,* median (Q1, Q3)	42 (31, 50)
Initial GCS score, median (Q1, Q3)	10 (3, 15)
Injury severity Score, median (Q1, Q3)	1 (1, 10)

GCS = Glasgow coma scale; Q1 = first quartile; Q3 = third quartile.
* Arterial blood gas data were available for 48 of 84 patients.

Table 2. Inpatient Clinical Characteristics

Total, N	84
PICU admission, n (%)	43 (51.2)
Cervical fracture, n	0
Seizure detected, n (%)	17 (20.2)
Pulmonary complications,*n (%)	16 (19.1)
Pneumonia, n (%)	8 (9.5)
Multiorgan failure, n (%)	10 (11.9)
Anoxic brain injury, n (%)	16 (19.3)
PICU length of stay, days, median (Q1, Q3)	1 (0, 2)
Ventilator days, median (Q1, Q3)	1 (1, 3)
Hospital length of stay, days, median (Q1, Q3)	2 (1, 3)

PICU = pediatric intensive care unit; Q1 = first quartile; Q3 = third quartile.
* Denotes both acute respiratory distress syndrome and pulmonary edema.

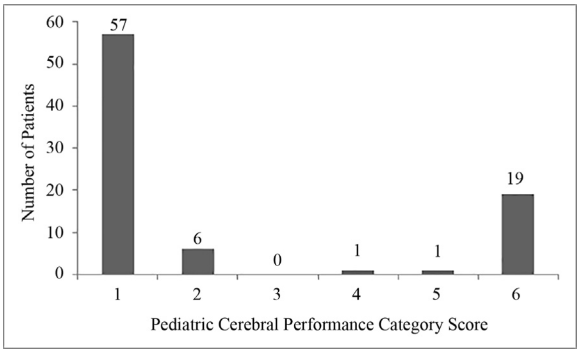

Figure 1. Bar graph showing the Pediatric Cerebral Performance Category score distribution for the entire cohort.

Table 3. Prehospital and Admission Characteristics, Compared by Patient Outcome

	PCPC Score 1–4	PCPC Score 5–6	*p* Value
Total, n (%)	64 (76.2)	20 (23.8)	
Male gender, n (%)	40 (62.5)	14 (70.0)	0.6
Prehospital cardiac arrest, n (%)	1 (1.6)	20 (100.0)	<0.0001
Age, y, median (Q1, Q3)	12 (4.5, 14)	8.5 (1.0, 12.5)	0.02
Arterial blood gas pH,* median (Q1, Q3)	7.3 (7.2, 7.4); n = 33/64 (52%)	6.9 (6.7, 7.0); n = 15 (75%)	<0.0001
Arterial blood gas CO2,* median (Q1, Q3)	41 (35, 48)	51.5 (18, 79)	0.3
Initial GCS score, median (Q1, Q3)	14 (7, 15)	3 (3, 3)	<0.0001
ISS, median (Q1, Q3)	1 (1, 10)	1 (1, 25.5)	0.9

ARDS = acute respiratory distress syndrome; GCS = Glasgow Coma Scale; ISS = Injury Severity Score; PCPC = Pediatric Cerebral Performance Category; PICU = pediatric intensive care unit; Q1 = first quartile; Q3 = third quartile.
* Arterial blood gas data were available for 48 of 84 patients.

Of those 6 patients, none had a prehospital cardiac arrest, and at the time of discharge, 5 patients had a PCPC score of 1 (normal), and 1 patient had a PCPC score of 2 (mild disability). One patient who was ultimately discharged with a PCPC score of 1 did have a prehospital cardiac arrest; however, this patient had a reported GCS score of 11 at the initial hospital evaluation.

Data obtained during hospitalization, including PICU admission/length of stay and complications of near-hanging, were also examined to determine if these factors correlated with outcome (Table 4). The unfavorable neurologic outcome group had a higher incidence of PICU admission (p = 0.02), a longer PICU length of stay (p = 0.001), and higher rates of pneumonia (p = 0.02) as well as pulmonary complications (pulmonary edema or ARDS, p = 0.002). The presence of multiorgan failure and anoxic brain injury were significantly different (p < 0.0001) between the two groups.

Nineteen children died during their hospital admission. Nine children underwent withdrawal of life support for presumed poor neurologic outcome after counseling from multiple services (PICU, neurology, or neurosurgery). Ten children died without withdrawal of life support. Patients who had life support withdrawn were more likely to have had significantly longer PICU and hospital lengths of stay (p = 0.02 for both), but no other metric (pH, partial pressure of carbon dioxide, initial GCS score, and Injury Severity Score) examined showed a significant difference between groups (Table 5).

DISCUSSION

To the best of our knowledge, this study represents the largest single-center cohort of children after near-hanging. Our findings contribute to the growing literature on neurologic outcome from near-hanging injury. Intentional self-strangulation with suicidal intent was the most common known reason for near-hanging in this cohort, and this finding parallels previous research (4,14). Previous adult studies have noted an association with neurologic outcome and multiple clinical, laboratory, and imaging features. Specifically, poor outcome has been associated with a clinical history of cardiac arrest hypotension at presentation, and an elevated Injury Severity Score (7–9,11,12,15,16). An initial acidotic blood gas has been associated with poor neurologic outcome, as has the presence of anoxic brain injury on initial imaging (8,11,12). Similarly, the limited pediatric evidence has noted an association of

Table 4. Inpatient Clinical Characteristics, Compared by Patient Outcome

	PCPC Score 1–4	PCPC Score 5–6	*p* Value
Total, n (%)	64 (76.2)	20 (23.8)	
PICU admission, n (%)	28 (43.7)	15 (75.0)	0.02
Seizure, n (%)	11 (17.2)	6 (30.0)	0.2
Pulmonary edema, n (%)	7 (10.9)	9 (45.0)	0.002
Pneumonia, n (%)	3 (4.7)	5 (25.0)	0.02
ARDS, n (%)	0 (0.0)	4 (20.0)	0.002
Multiorgan failure, n (%)	0 (0.0)	10 (50.0)	<.0001
Anoxic brain injury, n (%)	5 (7.8)	11 (57.9)	<.0001
PICU length of stay, days, median (Q1, Q3)	0 (0, 1)	2 (0.5, 4)	0.001
Ventilator days, median (Q1, Q3)	1 (1, 2)	2.5 (1, 4)	0.07
Hospital length of stay, days, median (Q1, Q3)	2 (1, 3)	2 (0.5, 4)	0.8

ARDS = acute respiratory distress syndrome; PCPC = Pediatric Cerebral Performance Category; PICU = pediatric intensive care unit; Q1 = first quartile; Q3 = third quartile.

Table 5. Prehospital and Inpatient Characteristics, Compared by End-of-Life Care

	Life Support Withdrawn	Mortality Without Life Support Withdrawn	*p* Value
Total, N	9	10	
Male gender, n (%)	6 (66.7)	7 (70.0)	1
Prehospital cardiac arrest, n (%)	9 (100)	10 (100)	N/A
Seizures, n (%)	4 (44.4)	1 (10.0)	0.1
Pulmonary edema, n (%)	5 (55.6)	4 (40.0)	0.7
Pneumonia, n (%)	2 (22.2)	3 (30.0)	1
ARDS, n (%)	3 (33.3)	1 (10.0)	0.3
Multiorgan failure, n (%)	6 (66.7)	4 (40.0)	0.4
Anoxic brain injury, n (%)	7 (77.8)	3 (33.3)	0.2
Age, y, median (Q1, Q3)	5 (1, 9)	11 (0.8, 13.0)	0.3
Arterial blood gas pH, median (Q1, Q3)	6.9 (6.6, 7.0)	6.8 (6.8, 6.9)	0.7
Arterial blood gas CO2, median (Q1, Q3)	47.5 (18.0, 56.0)	79 (58, 87)	0.1
Initial GCS score, median (Q1, Q3)	3 (3, 3)	3 (3, 3)	1
Injury Severity Score, median (Q1, Q3)	1 (1, 26)	1 (1, 25)	0.8
PICU length of stay, days, median (Q1, Q3)	4 (2, 6)	0.5 (0, 3)	0.02
Hospital length of stay, median (Q1, Q3), days	4 (2, 6)	0.5 (0, 3)	0.02

ARDS = acute respiratory distress syndrome; GCS = Glasgow Coma Scale; PICU = pediatric intensive care unit; Q1 = first quartile; Q3 = third quartile.

pulseless at the time of discovery with death and severe disability (10).

Consistent with a previous pediatric study of near-hanging, the majority of patients in our cohort were male, which is also similar in the adult literature (7,10,17,18). The median age of our cohort was 11.5 years, slightly lower than previous studies in which the median ages were adolescents (13–14 years of age) (3,10,14). In our study, the median PICU length of stay was 1 day, which is shorter than the mean of 4.4 days in a small cohort of 16 children reported by Hackett et al. (14). The difference in PICU length of stay is potentially related to differences in illness severity because 63% of their cohort required PICU admission, compared with 51% in our cohort, and their median duration of intubation was 2.2 days vs. 1 day in our cohort.

The rate of prehospital cardiopulmonary arrest was 25% within our cohort. This is lower than a previously published pediatric study in which 46% were found to be pulseless upon the arrival of emergency medical services (10). Our retrospective data show that several findings were associated with poor outcome: a prehospital history of cardiac arrest, an initial GCS score of 3T, and a lower initial pH; however, every patient with an unfavorable neurologic outcome (PCPC score of 5–6) presented with a GCS score of 3T and a history of prehospital cardiac arrest. No patients who ultimately had a favorable neurologic outcome (PCPC score of 1–4) presented with both GCS of 3T and prehospital cardiac arrest, and there were several patients who presented with one but not both of those findings who did have a good outcome at the time of discharge.

Previous studies have used injury details to prognosticate outcome. For instance, hanging time has been proposed to potentially risk-stratify outcome; however, such information is rarely known in pediatric hangings, as noted by our findings and those of others (10,12). In fact, hanging duration was not reported in this study because it was seldom evident in the medical record. The presenting GCS score alone has been previously offered as an indicator, and a low GCS score does have an association with poor outcome, as seen in our data, other single-center pediatric cohorts, and in analysis of national databases (9,10). However, our study and others have shown that near-hanging patients with poor initial GCS scores can still recover well (10,19). Therefore, to more accurately predict outcome, multiple factors need to be considered. Additional prehospital data may be insightful to emergency physicians who are actively working to stabilize the child. The prehospital data presented in this article were limited to the presence or absence of cardiac arrest. However, additional prehospital data should be evaluated in future studies and could include rates of endotracheal intubation, the presence or absence of hypoxemia, the presence or absence of hypotension, the first recorded heart rhythm, the presence or absence of bystander cardiopulmonary resuscitation, and relevant scene times.

Multiple complications associated with near-hanging injuries have been previously described. Complications seen in our cohort of patients that have been reported elsewhere include pneumonia, seizures, anoxic brain injury, ARDS, and postobstructive pulmonary edema (8,9,20). In our cohort, PICU admission, PICU length of stay, seizure, pulmonary complications (pulmonary edema or ARDS), pneumonia, multiorgan failure, and anoxic brain injury were all noted significantly more frequently in patients with worse outcome. The rate of anoxic brain injury in our cohort was 19%, similar to an adult study reporting a rate of 13% (8). However, multiorgan failure was seen exclusively in patients with a worse outcome.

An analysis of the U.S. National Trauma Data Bank found that 7% of patients presenting with hanging injury had a vertebral fracture and that there was a 3% incidence of spinal cord injury (9). Notably, cervical spine injury was not seen in our patients, consistent with a smaller study by Davies et al. in which no child who presented with a hanging injury had neither a cervical vertebral fracture nor cervical spinal cord injury (10). This difference may be attributable to a smaller drop height involved in pediatric near-hangings. In addition, the anatomy of pediatric patients may make them less prone to cervical spine fractures after near-hanging or hanging injuries. In an autopsy study of 307 hanging victims, age was felt to be an important variable in the presence or absence of cervical injury, with injury correlating with advancing age (21). Nonetheless, a high degree of suspicion for soft tissue injury should be used when treating near-hanging patients, especially when a poor neurologic examination makes examination more difficult (8,22,23).

Lung injury was noted in our patient population, and our findings are largely in agreement with previously published work. We and others have demonstrated that pulmonary edema after near-hanging can be seen even in patients who ultimately have a good neurologic outcome (20,24,25). We observed ARDS exclusively in patients who either died or were persistently comatose, and this is in contrast to previous adult studies that observed that some near-hanging patients with ARDS did make a meaningful recovery (15). Given the incidence of pulmonary complications—almost 20% in our study—clinicians must have a high suspicion for the potential development of pulmonary edema in patients with respiratory distress. In addition, clinicians may find that a lung protective, open-lung (higher positive end-expiratory pressure and a lower tidal volume) ventilator strategy within this cohort of patients may prove useful.

In many disease processes within pediatric neurocritical care, the natural reporting of the disease process is impacted by withdrawal of life support. Often following counseling regarding an expected poor neurologic outcome, families elect to withdraw life support as opposed to proceeding with formal brain death testing. To examine whether early withdrawal of life support might have impacted our results, we examined patients who ultimately died from their injuries and separated this group into patients who had life support withdrawn from patients who expired despite medical intervention. There were no significant differences noted apart from significantly longer hospital and PICU lengths of stay in the patients where life support was withdrawn, suggesting that early withdrawal of life support was not a confounding factor.

Limitations

There were several limitations to our study, notably the retrospective, single-center nature of the study. Although we tried to perform extraction of the medical record in a systematic manner, it is possible that some data were omitted. During the period encompassed by this project, our institution transitioned to an electronic medical record. Notably, some data were extrapolated from medical documentation, where there is the possibility of subjectivity in diagnosis of related conditions. During the 20-year time period of this study, medicine has evolved, and it is possible that identification and treatment strategies for similar disease processes have changed, which may have impacted our data. Lastly, our data were limited to short-term neurologic outcome; both functional and long-term outcome data were lacking. Future work should examine the question of prognosis after near-hanging injuries using a prospective design, multiple clinical sites, and formalized definitions for associated complications.

CONCLUSIONS

In this single-center retrospective analysis of children after a near-hanging event, we determined that patients who either died or were discharged in a comatose state uniformly had an initial presentation with prehospital cardiac arrest and a GCS score of 3T. This combination of findings was not seen in any patient who had a favorable neurologic outcome, defined as PCPC score of 1 to 4.

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ARTICLE SUMMARY

1. Why is this topic important?

Near-hanging is a common injury in the pediatric population. The majority of research examining this injury type has been conducted in adults.

2. What does this study attempt to show?

This study attempts to show key clinical factors that may portend poor outcome in this patient population.

3. What are the key findings?

Pediatric patients with near-hanging injury tended to dichotomize, ultimately either doing well or quite poorly. In patients who presented with an initial Glasgow Coma Scale score of 3T and prehospital cardiac arrest, there was uniform poor neurologic outcome.

4. How is patient care impacted?

This study may influence how caregivers advise families regarding prognosis in this patient population.