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Outcomes in 886 Critically Ill Patients after Near-Hanging Injury

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ABSTRACT

Background. Near-hanging is a life-threatening event about which few data are available.

Research question. What are the outcomes and early predictors of hospital mortality in critically ill patients with near-hanging.

Study Design and Methods. Adults patients with successful resuscitation of suicidal near-hanging injury admitted to 31 university or university-affiliated ICUs in France and Belgium between 1992 and 2014 were studied retrospectively. Cases were identified by searching the hospital databases for ICD-9 and ICD-10 codes and hospital charts for hanging for hanging. Logistic multivariate regression was performed to identify factors associated vital and functional outcomes at hospital discharge as the primary endpoints. Secondary outcomes were evaluation of temporal trends and identification of predictors of hospital mortality.

Results. Of the 886 patients (181 women and 705 men; median age, 43 years [34-52]), 266 (30.0%) had previously attempted suicide, 600 (67.7%) had a diagnosed mental illness, and 55 (6.2%) attempted hanging while hospitalised. Median time from hanging awareness to unhanging was 0 min [0-0] (range 0-82). Median Glasgow Coma Scale (GCS) score was 3 [3-5] at ICU admission. Hanging induced cardiac arrest in 450/886 (50.8%) patients. Overall, 497/886 (56.1%) patients were alive at hospital discharge, including 479/497 (96.4%) with a favourable neuro-cognitive outcome (defined as a Glasgow Outcome Scale score of 4-5). By multivariable analysis, factors associated with hospital mortality were hanging-induced cardiac arrest (OR, 19.50; 95%CI, 7.21-60.90; p<0.00001) and finding at ICU admission of glycemia >1.4 g/L (OR, 4.34; 95%CI, 1.82-10.81; p=0.0007) and lactate >3.5 mmol/L (OR, 9.98; 95%CI, 4.17-25.36; p<0.00001).

Interpretation. The findings from this large multicentre retrospective cohort emphasise the very high mortality after hanging injury due chiefly to hanging-induced cardiac arrest.

However, patients who survive after near-hanging have excellent neuro-cognitive recovery. Studies of early neuroprotective strategies for patients with near-hanging are warranted.

Keywords: Near-hanging. Intensive care unit. Coma/therapy. Outcome. Cardiopulmonary resuscitation.

INTRODUCTION

The frequency of suicide is increasing, and although many suicide attempts are unsuccessful, nearly 800,000 people die from suicide each year worldwide[1]. In adolescents and young adults, suicide is the second leading cause of death and is becoming increasingly common[2]. Among suicide methods, hanging is the most common in the world, has the third highest mortality rate[3], and is thought to be followed by severe residual anoxic brain damage in survivors

Near-hanging is defined as hanging or strangulation that does not immediately cause death.[4] Most cases are result from attempted suicide. Outcomes after near-hanging vary across studies[5,6], perhaps due in part to differences in patient inclusion criteria and management strategies[7]. No data are available on mortality and morbidity in patients who require intensive care unit (ICU) admission after near-hanging.

The primary objective of this multicentre retrospective study was to report vital and functional outcomes of critically ill patients with near-hanging. Additionally, we also evaluated changes in hospital mortality over the study period and identified predictors of hospital mortality in critically ill patients with near-hanging. Knowledge of such factors might help to identify areas for improving the management of adults with life-threatening near-hanging injury.

MATERIALS AND METHODS

Our local ethics committees (*Comité de Protection des Personnes de Paris, Ile de France XI,* 13 September 2012, #XI/12061 and *Comité Consultatif sur le Traitement de*

l'Information en matière de Recherche dans le domaine de la Santé, CCTIRS, 3 July 2013, #12.803Ter) approved this study and waived the requirement for informed consent in compliance with French and Belgian legislation on retrospective studies of anonymised data. The study was registered on Clinical Trials.gov under the number NCT04096976.

Study setting and patient management

In France and Belgium, the first responders to out-of-hospital health emergencies are fire squadrons and physician-staffed mobile emergency units capable of delivering advanced life support at the scene[8]. The closest emergency unit is dispatched to the scene in response to a call by a witness. Patients with a Glasgow Coma Scale (GCS) score below 8 and/or cardiac arrest may receive immediate endotracheal mechanical ventilation. Other life-supporting interventions are delivered on scene according to international guidelines. Similarly, the first responders to patients with in-hospital hanging are the bedside nurses and physicians, who provide basic resuscitation until advanced life-supporting interventions can be provided by the emergency-medicine, anaesthesiology, or ICU team[9]. Patients who do not recover fully are admitted to the ICU. Patients with cardiac arrest in whom the return to spontaneous circulation (ROSC) is not achieved are not eligible for ICU admission. Cervical spine computed tomography (CT) and CT angiography are performed when possible just before or after ICU admission.[4]

Study population

Consecutive adults admitted to 31 university or university-affiliated ICUs in France and Belgium after successful resuscitation of suicidal near-hanging injury between February 1992 and May 2014 were identified by searching the hospital databases for International Statistical Classification of Diseases and Related Health Problems (ICD), 9th and 10th Revisions: ICD-9

code E953.0 (“Suicide and self-inflicted injury by hanging”) ICD-10 code X70 (“Intentional self-harm by hanging, strangulation, and suffocation”). An additional search was performed on hospital charts using the word “hanging”. Local investigators reviewed the medical records of the patients thus identified to select adults admitted to the ICU after successfully resuscitated near-hanging injury. All patients older than 18 years who were admitted to the ICU due to self-inflicted in-hospital or out-of-hospital near-hanging injury were included.

Data collection

For each included patient, a standardised form was used to collect data on demographics, medical history, and the current near-hanging episode (setting, date and time of onset, clinical findings at the scene (Glasgow Coma Scale [GCS] score, body temperature, systolic blood pressure, heart rate, pulse oximetry, glycemia), and timing of supportive treatments). We also collected the laboratory findings at ICU admission (blood lactate, PaO_2, $PaCO_2$, serum sodium, and haemoglobin). Time from hanging discovery to unhanging was estimated based on pre-hospital, emergency-room, and ICU records. We also collected the results of imaging investigations for cervical and/or vascular injury. Finally, acute illness severity and organ failures were described using the Simplified Acute Physiology Score II (SAPS-II) and Logistic Organ Dysfunction (LOD) score, respectively.

Study outcomes

The primary objective was to report vital and functional outcomes of critically ill patients with near-hanging. Good functional outcome was defined as a Glasgow Outcome Scale score of 4 or 5. Secondary objectives were to evaluate changes in hospital mortality over the last two decades, and to identify predictors of hospital mortality in critically ill patients with near-hanging.

Statistical analysis

Quantitative parameters were described as median (interquartile range [IQR]) and qualitative parameters as number (percentage). We compared categorical variables using Fisher's exact tests, continuous variables using Wilcoxon rank-sum tests, and ordered categorical variables using chi-square and Kruskal-Wallis tests. Hospital survival was the primary outcome measure.

To evaluate changes in hospital mortality over time, the 23-year study period was divided into five consecutive intervals. Differences were assessed with the Mantel-Haenszel chi-square test of linear association for categorical variables. Analysis of variance and Kruskal-Wallis tests were used to compare means and medians.

To identify associations between factors listed in Table 1 and hospital mortality, we used logistic regression. Before performing the multivariate logistic regression analysis, all continuous variables were checked for log-linearity. Non-log-linear variables were transformed into dummy variables according to their inflexion point or median value. Non-collinear variables that yielded *p* values smaller than 0.05 by univariate analysis and clinically relevant were considered for the multivariable model. The five consecutive intervals over the study period described above and SAPS II score on day 1 were used for adjustment. The variables included in the multivariate model selection process were Male gender, Alcohol abuse; Previous suicide attempt, Time from hanging discovery to unhanging >5 min; Call for EMS before unhanging; Hanging-induced cardiac arrest; Total number of organ failures at day 1 > 2; Lactate > 3.5 mmol/L at ICU admission; Body temperature >36.5°C at ICU admission; Glycaemia >1.4 g/L at ICU admission; Pulse oximetry > 92% at ICU admission; Glasgow Coma Scale score > 5 at admission, Cervical spine and/or vascular injury at ICU admission. Selection of the variables was performed using stepwise model selection guided by Akaike Information Criterion. The Hosmer-Lemeshow goodness-of-fit test and area under

the receiver operating characteristics curve (AUC-ROC) estimated by the C-statistic were computed on the final models. Associations of factors with hospital mortality are reported as odds ratios (ORs) with their 95% confidence intervals (95%CIs). To test the robustness of our results, under the hypothesis of data missing at random, we performed a sensitivity analysis after multiple imputation for missing data by means of chained equations (66 imputations, 10 iterations).

All tests were two sided and *p* values <0.05 were considered significant.

Analyses were performed using R statistical software version 4.0.0 (R Foundation for Statistical Computing, Vienna, Austria)*.

*http://www.R-project.org. Accessed June 15, 2020

RESULTS

Figure 1 is the patient flow chart. The study included 886 adults admitted to the 31 study ICUs in France and Belgium over the 23-year study period.

Patient features and early management

Figure 1 and Table 1 report the main patient features and early interventions. Most patients (67.7%) had a known mental illness and 266/886 (30.0%) had previously attempted suicide. Hanging occurred at home in 696/886 (79%) patients, in a correctional facility in 61/886 (7%) patients, in a hospital ward in 55/886 (6%) patients, out of doors in 48/886 (5%) patients, and at other locations in 26/886 (3%) patients. All but 65/886 (7.3%) patients required endotracheal mechanical ventilation at the scene. Hanging-induced cardiac arrest occurred in 450/886 (50.8%) patients.

ICU management and outcomes

At ICU admission, median number of organ failures was 3 [2-3]. Endotracheal mechanical ventilation was required during the ICU stay in 15 additional patients. Imaging investigations to look for cartilage, bone, and/or vascular injuries at the neck were performed in about three-fourths of our patients. Injuries were found on admission brain and cervical CT scan or MRI in only 40/683 (5.9%) of patients: cervical spine in 32 and, vascular in 8, and intracerebral haemorrhage in 3 (patients may have more than one complication). Targeted temperature management to 32-34°C was used in 259/886 (29%) patients, including 217/450 with hanging-induced cardiac arrest, for a median of 24 [23-24] hours. Complications occurred in 33/259 patients: infection in 9, arrhythmia in 9, bleeding in 3 and hemodynamic instability during rewarming in 14. Overall, 497/886 (56.1%) patients survived to hospital

84%

discharge, of which 418/497 did not experienced hanging-induced cardiac arrest. Of the 389 other patients, 169/389 (43.4%) died after decisions to withhold and/or withdraw life-sustaining treatments. Brain death occurred in 123/389 (31.6%) of the patients who died, within a median of 4 [2-5] days after hanging. Median hospital stay lengths in survivors and non-survivors were 4 [3-9] and 5 [2-8] days, respectively. Finally, among the 497 survivors, 479 (96.4%) had a favourable outcome at hospital discharge defined as a GOS score of 4 or 5, and 18 had an unfavourable outcome including 2 patients in a vegetative state (GOS score of 2).

Time trends in hospital mortality over the 23-year study period

Table 2 reports time trends of hospital mortality according to patient characteristics over the 23-year study period separated into five roughly equal intervals. Crude hospital mortality decreased significantly over time (p=0.01). Several parameters associated with mortality became more common (p<0.001) including hanging-induced cardiac arrest, call for EMS before unhanging and time from hanging discovery to unhanging, Glasgow Coma Scale score impairment at ICU admission, body temperature and glycaemia at ICU admission; worse day-1 SAPS II and LOD score values, and decisions to limit life-sustaining treatments.

Factors associated with hospital mortality

Table 3 reports the results of the multivariable analysis in all patients with near-hanging injury. After adjustment on the five time intervals and SAPS II score on day 1, factors significantly associated with hospital mortality were hanging-induced cardiac arrest (OR, 19.50; 95%CI, 7.21-60.90; p<0.00001) and finding at ICU admission of glycemia >1.4 g/L (OR, 4.34; 95%CI, 1.82-10.81; p=0.0007) and lactate >3.5 mmol/L (OR, 9.98; 95%CI, 4.17-25.36; p<0.00001). The sensitivity analysis performed after multiple imputation for missing

data produced similar results in addition to the impact of the weight of organ failures and alcohol abuse.

DISCUSSION

To our knowledge, this study is the largest providing detailed information on the epidemiology and outcomes of patients admitted to the ICU for near-hanging injury. Overall, slightly over half the patients survived to hospital discharge, and most survivors had a favourable outcome defined as a Glasgow Outcome Scale score of 4 or 5 at discharge. The most powerful determinants of hospital mortality were complications of hanging injury, namely, hanging-induced cardiac arrest, hyperglycaemia and high blood lactate at ICU admission.

Published studies of patients with near-hanging were retrospective, as was ours, but included far fewer patients, usually from a single centre. In keeping with their results, we found a strong predominance of males and of patients with at least one psychiatric diagnosis[10-16]. Also consistent with earlier findings, nearly a third of our patients had previously attempted suicide, although only rarely by hanging [14]; about a fourth had an alcohol addiction; and about a tenth abused other substances[14]. Hanging usually occurred at home, although a few patients were in correctional facilities or psychiatric institutions[4].

Cardiac arrest is among the most severe complications of hanging. The frequency of reported cardiac arrest varies considerably across studies, from 3%[14] to 47%[16]. Another source of variability probably lies in the differences in healthcare resources across countries, which govern in part the time to arrival of the first responders and, therefore, the risk of cardiac arrest occurring and the chances of surviving to hospital admission, which is required for inclusion in studies. Also, cardiac arrest is probably more common in studies of

emergency room and ICU patients compared to studies of ward patients. Thus, that half our patients had cardiac arrest reflects the severity of hanging injuries requiring ICU admission.

Factors similar to those affecting the risk of cardiac arrest may be involved in the substantial variability in reported hospital mortality rates, from about 10% to almost 80%[12,16-18]. This variability contrasts sharply with the finding in most studies that about 10% of survivors had residual neurological impairments responsible for dependency[10,11,13,14,16,19]. Selection bias may therefore contribute to the variations in hospital mortality. Thus, some studies excluded patients with successfully resuscitated cardiac arrest or with a full neurological recovery after pre-hospital care, and others included all admitted patients regardless of department of admission. We included only patients requiring ICU admission, among whom cardiac arrest is far more common than in the overall population of hanging-injury patients.

Of the three factors independently associated with hospital mortality in our study, hanging-induced cardiac arrest and worse consciousness impairment at ICU admission are directly related to the hanging, whereas higher glycaemia and lactate levels at ICU admission represent biochemical markers of physiologic perturbation and injury severity that may suggest avenues for improvement in pre-hospital care. Cardiac arrest may be triggered by anoxia, strong intense reflex activation of the autonomic nervous system, intracranial hypertension or, more rarely, spinal cord injuries.[4] Importantly, cerebral anoxia may be related to cardiac arrest and/or to compression of the cervical blood vessels during hanging.[4,14] Cerebral imaging studies, when performed, have shown oedema, ischemia[10,13,17-21], and subarachnoid bleeding from cervical arteries. Subdural haematoma has been found in nearly one fourth of patients and usually ascribed to a head injury sustained during unhanging[17]. However, even if determining the time of hanging is an inherent difficulty due to the particular context of self-inflicted near-hanging injury, the most probable reason explaining

hanging-induced cardiac arrest occurrence is related to prolonged hanging, responsible for prolonged asphyxiation and hypoxemia. Thus, as in other causes of hypoxic cardiac arrest, hanging-induced cardiac arrest is associated with high hospital mortality rates[18]. Hyperglycaemia is among the secondary brain insults known to be associated with worse outcomes of traumatic brain injury, stroke, subarachnoid haemorrhage or cardiac arrest. Strong experimental data suggest that tight glycaemia control might improve outcomes but have not been supported by clinical studies[22,23]. Hyperglycaemia was associated with lower hospital survival in our population and in an earlier report.[16] No study has focussed specifically on assessing therapeutic interventions for preventing hyperglycaemia after near-hanging injury. High lactate levels at ICU admission, the third independent predictor of hospital mortality in our patients, indicates severe anoxia and post-resuscitation syndrome. High lactate is strongly associated with poor outcomes after cardiac arrest.[24-26] Finally, none of the circumstances of the hanging injuries assessed in our study were independently associated with the outcomes.

Traumatic injury to the airway cartilage and bones, cervical vertebrae, and/or cervical blood vessels may also be life-threatening but is uncommon. Injuries were found in only 6% of patients. In a smaller cohort of 161 patients, spinal lesions were detected in only 2% and vascular lesions in 0.5% of patients[14]. There is no consensus about the appropriate workup for these patients. However, given the inability to identify patients pre-imaging who are at risk of cervical injury, it has been suggested that imaging studies can be performed in all patients with near-hanging injury.[5]

Our comparison of five successive time intervals over the 23-year study period showed several changes. Age varied among the 5 temporal intervals, ranging from 39 [31-47] to 47 [39-55] years. However, we believe this difference is not clinically relevant even if statistically significant. The most striking of these is the increase in the proportion of patients

with hanging-induced cardiac arrest, from 29.3% in the earliest interval to 59.9% in the most recent interval, which probably explains the increases in the SAPS II and LOD score and in the proportion of patients with decisions to limit life-sustaining treatments, as well as the decrease in the GCS score. In theory, increased mortality might be a marker for decreased effectiveness of care. However, the only major change in management during the study period was the introduction in 2002 of targeted temperature management in those patients still comatose after successfully resuscitated cardiac arrest. Several studies have shown benefits from targeted temperature management after hanging-induced cardiac arrest[18,19,27,28]. One hypothesis is that advances in pre-hospital care may have increased the proportion of patients who survive to hospital admission but also the proportion of admitted patients with the most severe forms of near-hanging injury. This hypothesis is consistent with the greater frequency of cardiac arrest and worse GCS scores in the patients admitted more recently.

Our study has several limitations, in addition to the retrospective design. First, our findings are relevant only to those patients with near-hanging injury who are admitted to the ICU. Our population was thus at the severe end of the clinical spectrum of patients who survive hanging until they are admitted. Second, the long study period may have resulted in heterogeneity of the population and therapeutic interventions. However, the multivariate analysis was adjusted for time period. Moreover, a long study period was necessary to obtain a large sample, given the low frequency of near-hanging injury. Our study describes the largest cohort to date and provides a realistic picture of the ICU management and outcomes of patients with near-hanging injury over the last two decades. Third, the long study period resulted in a high rate of missing data that could have biased our findings. To go beyond this limitation, we carried out sensitivity analysis after multiple imputation for missing data by means of chained equations which reinforces confidence in our findings.

INTERPRETATION

The findings from this large multicentre retrospective cohort emphasise the very high mortality after hanging injury due chiefly to hanging-induced cardiac arrest. However, patients who survive after near-hanging have excellent neuro-cognitive recovery. Studies of early neuroprotective strategies for patients with near-hanging are warranted.

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Conflicts of interest

None of the authors has any conflicts of interest to declare.

Authors' contributions

Stephane Legriel, conceived, designed, and supervised the trial.

Stephane Legriel, Louise de Charentenay, Marc Danguy des Déserts, Guillaume Schnell, Nicolas Pichon, Jean-Baptiste Lascarrou, Jonathan Chelly, Marc Simon, Charlotte Martin, Gwenaelle Jacq and Caroline Durant, collected the data; and Stephane Legriel coordinated the data collection.

Stephane Legriel, Louise de Charentenay, and Marie Salvetti analysed and interpreted the data.

Stephane Legriel performed the statistical analysis.

Stephane Legriel, Louise de Charentenay, and Marie Salvetti wrote the first draft of the paper. All authors revised the manuscript for important intellectual content and approved the final version of the manuscript.

References

1. Ajdacic-Gross V, Weiss MG, Ring M, et al. Methods of suicide: international suicide patterns derived from the WHO mortality database. *Bulletin of the World Health Organization*. 2008;86:726-732.
2. Yu B, Chen X. Age and Birth Cohort-Adjusted Rates of Suicide Mortality Among US Male and Female Youths Aged 10 to 19 Years From 1999 to 2017. *JAMA Netw Open*. 2019;2(9):e1911383.
3. Spicer RS, Miller TR. Suicide acts in 8 states: incidence and case fatality rates by demographics and method. *Am J Public Health*. 2000;90(12):1885-1891.
4. Ramakrishnan T. Near Hanging. *Clinical Pathways in Emergency Medicine*: Springer; 2016:497-502.
5. Schellenberg M, Inaba K, Warriner Z, et al. Near hangings: Epidemiology, injuries, and investigations. *J Trauma Acute Care Surg*. 2019;86(3):454-457.
6. Jawaid MT, Amalnath SD, Subrahmanyam DKS. Neurological Outcomes Following Suicidal Hanging: A Prospective Study of 101 Patients. *Ann Indian Acad Neurol*. 2017;20(2):106-108.
7. Tharmarajah M, Ijaz H, Vallabhai M, et al. Reducing mortality in near-hanging patients with a novel early management protocol. *Am J Emerg Med*. 2018;36(11):2050-2053.
8. Adnet F, Lapostolle F. International EMS systems: France. *Resuscitation*. 2004;63(1):7-9.
9. Jung B, Daurat A, De Jong A, et al. Rapid response team and hospital mortality in hospitalized patients. *Intensive Care Med*. 2016;42(4):494-504.
10. Salim A, Martin M, Sangthong B, Brown C, Rhee P, Demetriades D. Near-hanging injuries: a 10-year experience. *Injury*. 2006;37(5):435-439.
11. Penney DJ, Stewart AH, Parr MJ. Prognostic outcome indicators following hanging injuries. *Resuscitation*. 2002;54(1):27-29.
12. Matsuyama T, Okuchi K, Seki T, Murao Y. Prognostic factors in hanging injuries. *Am J Emerg Med*. 2004;22(3):207-210.
13. Martin MJ, Weng J, Demetriades D, Salim A. Patterns of injury and functional outcome after hanging: analysis of the National Trauma Data Bank. *Am J Surg*. 2005;190(6):836-840.
14. Boots RJ, Joyce C, Mullany DV, et al. Near-hanging as presenting to hospitals in Queensland: recommendations for practice. *Anaesth Intensive Care*. 2006;34(6):736-745.
15. Wee JH, Park JH, Choi SP, Park KN. Outcomes of patients admitted for hanging injuries with decreased consciousness but without cardiac arrest. *Am J Emerg Med*. 2013;31(12):1666-1670.
16. Gantois G, Parmentier-Decrucq E, Duburcq T, Favory R, Mathieu D, Poissy J. Prognosis at 6 and 12months after self-attempted hanging. *Am J Emerg Med*. 2017;35(11):1672-1676.
17. Solhi H, Pazoki S, Mehrpour O, Alfred S. Epidemiology and prognostic factors in cases of near hanging presenting to a referral hospital in Arak, Iran. *J Emerg Med*. 2012;43(4):599-604.
18. Hsu CH, Haac BE, Drake M, et al. EAST Multicenter Trial on targeted temperature management for hanging-induced cardiac arrest. *J Trauma Acute Care Surg*. 2018;85(1):37-47.

19. Hsu CH, Haac B, McQuillan KA, Tisherman SA, Scalea TM, Stein DM. Outcome of suicidal hanging patients and the role of targeted temperature management in hanging-induced cardiac arrest. *J Trauma Acute Care Surg*. 2017;82(2):387-391.
20. Kim MJ, Yoon YS, Park JM, et al. Neurologic outcome of comatose survivors after hanging: a retrospective multicenter study. *Am J Emerg Med*. 2016;34(8):1467-1472.
21. Nichols SD, McCarthy MC, Ekeh AP, Woods RJ, Walusimbi MS, Saxe JM. Outcome of cervical near-hanging injuries. *J Trauma*. 2009;66(1):174-178.
22. Van den Berghe G, Schoonheydt K, Becx P, Bruyninckx F, Wouters PJ. Insulin therapy protects the central and peripheral nervous system of intensive care patients. *Neurology*. 2005;64(8):1348-1353.
23. Johnston KC, Bruno A, Pauls Q, et al. Intensive vs Standard Treatment of Hyperglycemia and Functional Outcome in Patients With Acute Ischemic Stroke: The SHINE Randomized Clinical Trial. *JAMA*. 2019;322(4):326-335.
24. During J, Dankiewicz J, Cronberg T, et al. Lactate, lactate clearance and outcome after cardiac arrest: A post-hoc analysis of the TTM-Trial. *Acta Anaesthesiol Scand*. 2018;62(10):1436-1442.
25. Kong T, Chung SP, Lee HS, et al. The Prognostic Usefulness of The Lactate/Albumin Ratio For Predicting Clinical Outcomes In Out-Of-Hospital Cardiac Arrest: A Prospective, Multicentre Observational Study (KoCARC Study). *Shock*. 2019.
26. Dell'Anna AM, Sandroni C, Lamanna I, et al. Prognostic implications of blood lactate concentrations after cardiac arrest: a retrospective study. *Ann Intensive Care*. 2017;7(1):101.
27. Legriel S, Bouyon A, Nekhili N, et al. Therapeutic hypothermia for coma after cardiorespiratory arrest caused by hanging. *Resuscitation*. 2005;67(1):143-144.
28. Shin J, Lee H, Kim J, et al. Outcomes of hanging-induced cardiac arrest patients who underwent therapeutic hypothermia: a multicenter retrospective cohort study. *Resuscitation*. 2014;85(8):1047-1051.

Table 1. Factors associated with hospital mortality in 886 patients with self-inflicted near-hanging injury

Factors associated with hospital mortality	N (%) or Median [interquartile range]				Univariate analysis		
	All patients n=886 (100%)	N Missing	Survived to hospital discharge n=497 (56.1%)	Died in the hospital n=389 (43.9%)	OR	95%CI	*p* value
Demographics and patient features							
Male gender	705 (79.6%)	0	409 (82.3%)	296 (76.1%)	0.68	0.49-0.95	0.02
Age (years)	43 [34-52]	0	42 [34-50]	44 [34-54]	1.01	1.00-1.01	0.27
At least one psychiatric comorbidity	609 (67.7%)	0	338 (68.0%)	262 (67.4%)	0.87	0.73-1.29	0.84
Number of chronic psychiatric treatments	0 [0-2]	0	0 [0-2]	0 [0-2]	1.02	0.91-1.13	0.79
Alcohol abuse	232 (26.2 %)	0	148 (29.8%)	84 (21.6%)	0.65	0.48-0.88	0.006
Other substance abuse	83 (9.4 %)	0	54 (10.9 %)	29 (7.5%)	0.66	0.41-1.06	0.09
Previous suicide attempts	266 (30.0%)	0	163 (32.8%)	103 (26.5%)	0.74	0.55-0.99	0.04
Previous hanging attempt	58 (6.6%)	0	37 (7.4%)	21 (5.4%)	0.71	0.41-1.23	0.22
Presumed ultimately fatal comorbidity†	21 (2.4%)	0	13 (2.6%)	8 (2.1%)	0.78	0.32-1.92	0.59
On-scene characteristics		0					
In-hospital hanging attempt	55 (6.2 %)	0	30 (6.0%)	25 (6.4%)	1.06	0.62-1.85	0.81
Time from hanging discovery to unhanging (min)	0 [0-0]	149	0 [0-0]	0 [0-5]	1.02	1.01-1.04	0.008
Call for EMS before unhanging	165 (21.1%)	102	68 (15.6%)	97 (27.8%)	2.08	1.47-2.95	<0.0001
Hanging-induced cardiac arrest	450 (50.8 %)	0	79 (15.9%)	371 (95.4%)	109.1	64.1-185.4	<0.0001
Glasgow Coma Scale score	3 [3-5]	158	5 [3-7]	3 [3-3]	0.17	0.12-0.24	<0.0001
Clinical, laboratory, and imaging findings at ICU admission							
Glasgow Coma Scale score	3 [3-5]	158	5 [3-7]	3 [3-3]	0.28	0.22-0.37	<0.0001
Body temperature (°C)	36.5 [35.4-37.1]	82	36.8 [36.2-37.4]	35.5 [34.5-36.8]	0.58	0.52-0.65	<0.0001
Systolic blood pressure (mmHg)	115 [99-135]	98	115 [100-130]	115 [94-140]	1.00	1.00-1.01	0.41
Pulse oximetry (%)	99 [97-100]	41	99 [98-100]	99 [96-100]	0.90	0.86-0.94	<0.0001
Glycaemia (g/L)	1.42 [1.07-2.23]	111	1.2 [0.98-1.51]	2.22 [1.47-2.87]	5.52	4.23-7.20	<0.0001
Lactate (mmol/L)	3.5 [1.9-7.8]	338	2.2 [1.4-3.1]	7.6 [4.7-11.0]	1.40	1.31-1.49	<0.0001
PaO_2/FiO_2 (mmHg/%)	331 [211.1-457]	132	335 [225-457]	322 [201-457]	1.00	1.00-1.00	0.25
$PaCO_2$ (mmHg)	38 [32-44]	84	37 [33-43]	38 [31-45]	1.00	0.99-1.01	0.72
Serum sodium (mmol/L)	140 [137-142]	68	140 [138-142]	139 [137-142]	0.98	0.95-1.01	0.27
Haemoglobin (g/dL)	14.4 [13.3-15.7]	114	14.1 [13.1-14.9]	15.1 [13.8-16.6]	1.44	1.32-1.58	<0.0001
Cervical spine and/or vascular injury on admission CT or MRI (n=683)	40 (5.9 %)	203	17 (4.3 %)	23 (8.1 %)	1.97	1.03-3.75	0.04
Severity scores at hospital admission							
SAPS II at day 1	51 [43-63]	45	45 [37-53]	62 [51-72]	1.10	1.08-1.11	<0.0001
Total number of organ failures at day 1*	3 [2-3]	0	2 [2-3]	3 [3-4]	3.79	3.09-4.64	<0.0001

EMS, emergency medical system; $PaCO_2$, arterial partial pressure of carbon dioxide**;** PaO_2, arterial partial pressure of oxygen; FiO_2, fractional inspired oxygen; CT, computed tomography; MRI, magnetic resonance imaging; SAPS II, Simplified Acute Physiology Score II; LOD, Logistic Organ Dysfunction system score; OR, odds ratio; 95%CI, 95% confidence interval; ICU, intensive care unit

† According to the McCabe classification

* according to Logistic Organ Dysfunction score

Table 2. Time Trends of Hospital Mortality According to Characteristics of the Patients and Near-Hanging Injuries from 1992 to 2014

Mortality at hospital discharge	N(%) or Median [interquartile range]					
	1992-1995 n=13/41 (31.7%)	1996-2000 n=40/119 (33.6%)	2001-2005 n=95/229 (41.5%)	2006-2010 n=148/315 (47.0%)	2011-2014 n=93 /182 (51.1%)	*p* value for trend
Male gender	9 (69.2%)	30 (75.0%)	75 (78.9%)	118 (79.7%)	64 (68.8%)	0.65
Age (years)	40 [33 - 48]	36 [28 - 46]	41 [32 - 50]	45 [35 - 56]	48 [42 - 57]	1.00
Presumed ultimately fatal comorbidity†	0	2 (5.0%)	0	4 (2.7%)	2 (2.2%)	1.00
In-hospital hanging attempt	1 (2.4%)	7 (5.9%)	14 (6.1%)	17 (5.4%)	16 (8.9%)	1.00
Call for EMS before unhanging	4 (36.7%)	15 (41.7%)	20 (24.7%)	34 (25.6%)	24 (27.3%)	< 0.001
Time from hanging discovery to unhanging (min)	0 [0 - 10]	0 [0 - 7]	0 [0 - 3]	0 [0 - 3]	0 [0 - 4]	0.001
Hanging-induced cardiac arrest	12 (92.3%)	36 (90.0%)	91 (95.8%)	141 (95.3%)	91 (97.9%)	< 0.0001
GCS score at ICU admission	3 [3 - 3]	3 [3 - 3]	3 [3 - 3]	3 [3 - 3]	3 [3 - 3]	< 0.0001
Body temperature (°C) at ICU admission	36.2 [33.9 - 37.1]	36.5 [35.5 - 37.3]	33.5 [34.6 - 36.5]	35.3 [34.3 - 36.2]	35.5 [34.4- 37.0]	< 0.0001
Glycaemia (mmol/L) at ICU admission	2.8 [2.2 - 3.7]	2.0 [1.6 - 2.8]	2.2 [1.7 - 3.1]	2.3 [1.5 - 2.9]	2.1 [1.3 - 2.7]	< 0.0001
Lactate (mmol/L) at ICU admission	7.4 [3.8 - 7.9]	6.8 [4.1 - 9.9]	7.6 [5.0 - 11.9]	7.6 [4.9 – 11.0]	7.9 [4.6 – 11.0]	< 0.0001
Cervical spine and/or vascular injury at ICU admission	1 (12.5%)	1 (5.3%)	10 (12.8%)	10 (8.9%)	1 (1.5%)	1.00
Targeted temperature management (32-36°C)	3 (23.1%)	10 (25.0%)	26 (27.4%)	82 (55.4%)	64 (68.8%)	< 0.0001
Withholding/Withdrawal of life-sustaining treatment	1 (7.7%)	8 (20.0%)	28 (29.5%)	78 (52.7%)	51 (54.8%)	< 0.0001
SAPS II on day 1	52 [47 - 62]	63 [49 - 74]	58 [48 - 70]	63 [53 - 75]	63 [55 - 73]	< 0.0001
Total number of organ failures at day 1*	3 [3 - 4]	3 [2 - 4]	3 [2 - 4]	3 [3 - 4]	3 [2 - 4]	< 0.0001
LOD score on day 1	9 [7 - 9]	8 [6 - 9]	8 [7 - 10]	8 [7 - 10]	7 [6 - 10]	< 0.0001

ICU, intensive care unit; SAPS II, Simplified Acute Physiology Score II, LOD, Logistic Organ Dysfunction

† According to the McCabe classification

* According to Logistic Organ Dysfunction score

Table 3. Predictors of mortality at hospital discharge in 886 patients admitted to the ICU for near-hanging injury, adjusted on time of occurrence between 1992 and 2014 and SAPS II score at day 1

	Multivariate analysis‡ Complete cases (n=314)			Multivariate analysis‡ MICE (FMD 65%)		
	OR	95%CI	*p* value	OR	95%CI	*p* value
Time from hanging discovery to unhanging >5 min	-	-	-	2.18	0.66-7.21	0.20
Call for EMS before unhanging	-	-	-	0.76	0.97-1.98	0.57
Hanging-induced cardiac arrest	19.50	7.21-60.90	<0.00001	36.69	18.63-72.23	<0.00001
Total number of organ failures at day 1 > 2*	1.45	0.58-3.59	0.16	2.10	1.18-3.66	0.01
Lactate > 3.5 mmol/L at ICU admission	9.98	4.17-25.36	<0.00001	7.65	3.50-16.69	<0.00001
Body temperature >36.5°C at ICU admission	0.42	0.17-1.03	0.46	0.61	0.33-1.13	0.18
Glycaemia >1.4 g/L at ICU admission	4.34	1.82-10.81	0.0007	3.50	1.88-6.52	<0.00001
Alcohol abuse	0.51	0.18-1.40	0.19	0.50	0.03-0.98	0.046
Cervical spine and/or vascular injury at ICU admission**	0.49	0.05-5.46	0.63	3.69	0.86-15.81	0.08

EMS, emergency medical services; ICU, intensive care unit; MICE, MICE package in R for multivariate imputation; FMD 66%

* According to Logistic Organ Dysfunction Score

‡ adjusted according to time of management: 1992-1995, 1996-2000, 2001-2005, 2006-2010, or 2011-2014 and to SAPS2 score at day 1 after ICU admission.

** among the 683 patients who underwent CT or MRI

Variables selected for the model selection process: Male gender, Alcohol abuse; Previous suicide attempt, Time from hanging discovery to unhanging >5 min; Call for EMS before unhanging; Hanging-induced cardiac arrest; Total number of organ failures at day 1 > 2; Lactate > 3.5 mmol/L at ICU admission; Body temperature >36.5°C at ICU admission; Glycaemia >1.4 g/L at ICU admission; Pulse oximetry > 92% at ICU admission; Glasgow Coma Scale score > 5 at admission, Cervical spine and/or vascular injury at ICU admission.

Goodness of fit (Hosmer Lemeshow) chi-square *p* value, 0.16; Area under ROC curve, 0.96

886 adults with self-inflicted near hanging injury in 31 ICUs in France and Belgium over a 23-year period (1992-2014)

Male gender	705 (79.6%)
Age	43 (34-52)
In-hospital hanging attempt	55 (6.2%)
Hanging-induced cardiac arrest	450 (50.8%)
Glasgow Coma Scale score on scene	3 (3-5)
Cervical spine and/or vascular injury on admission CT or MRI (n=683)	40 (5.9%)
Median number of organ failures on day 1	3 (2-3)
Neurological failure	839 (94.7%)
Respiratory failure	821 (92.7%)
Renal failure	355 (40.1%)
Cardiovascular failure	244 (27.5%)
Liver failure	49 (5.5%)
Haematological failure	28 (3.1%)

389/886 (43.9%) GOS 5

497/886 (56.1%) patients alive at hospital discharge

479/886 (54.1%) GOS 4-5

18/886 (2.0%) GOS 2-3

Abbreviations list

ICU (Intensive care unit)

GCS (Glasgow Coma Scale)

ROSC (Return to spontaneous circulation)

CT (Computed tomography)

ICD (International Statistical Classification of Diseases and Related Health Problems)

SAPS-II (Simplified Acute Physiology Score II)

LOD (Logistic Organ Dysfunction)

IQR (Score interquartile range)

AUC-ROC (Area under the receiver operating characteristics curve)

ORs (Odds ratios)