

Magnetic Resonance Imaging Neurological Findings in Indian Patients who Survived Suicidal Hanging - A Retrospective Study

Das U¹, Biswas J², Pandit N¹, Bhadra T³

¹ Department of Radiodiagnosis, North Bengal Medical College and Hospital, India.

² Department of Forensic Medicine and Toxicology, North Bengal Medical College and Hospital, India.

³ Department of General Medicine, North Bengal Medical College and Hospital, India.

Abstract

Background: Hanging is a common mode of suicide. Every year, more than 100,000 people commit suicide in our country. Although there are a few studies describing Computed Tomography (CT) findings of the neuroaxis in cases of hanging, studies describing findings in Magnetic Resonance Imaging (MRI) are only a handful. The reason is that most of these patients usually die due to a narrow fatal period of 3 to 5 minutes before they reach the hospital. Among those who reach the hospital, the poor general condition doesn't allow the long time required for an MRI.

Method: A retrospective study was conducted where the neuroimaging findings in MRI in patients referred from various departments with a history of hanging between June 2020 to June 2023 were analyzed.

Results: The study included 74 cases of non-fatal hanging, with only 29.72% of cases showing neuroimaging abnormalities (NIA). Adult-type hypoxic-ischemic encephalopathy was the most common NIA (13.51%), with fronto-parieto-occipital lobe involvement in 100% and temporal lobe involvement in 40% of cases. Spinal cord injury manifesting as cord signal hyperintensity was seen among 18.18% of the study population. Other miscellaneous findings included vascular, bony, spinal cord, and neck muscle injuries in 18.18%, 18.18%, 9%, and 37.84% cases respectively.

Conclusion: Most cases of non-fatal hanging show no pathological NIA. Among those with NIA, the findings are predominantly reflective of acute global hypoxic injury. Further investigation and large-scale studies are needed to better understand the pathophysiology of the condition and prognosticate these patients based on neuroimaging findings.

Key words

Hanging, Suicide, Magnetic Resonance Imaging

Introduction

Hanging (self-suspension) is a form of asphyxia that is caused by the suspension of the body by a ligature that encircles the neck, the constricting force being the weight of the body. Hanging is a very common mode of suicide. In some nations, hanging is also practiced as capital punishment. Death in hanging is due to a combination of asphyxia and cerebral anemia rather than injury to the spinal cord (Reddy and Murthy, 2014). This must be an important consideration that physicians must consider while treating hanging survivors. Computed Tomography (CT) brain findings consistent with global cerebral hypoxia have been reported by some authors. Magnetic Resonance Imaging (MRI) brain findings consistent with severe acute global cerebral hypoperfusion have also been reported. Most of these cases have reported findings to be present bilaterally (Binaco and Floris, 1987; Brancatelli et al., 2000). There is very limited research describing the neuroimaging findings in hanging patients in MRI. The most logical explanation of this cause is the very short fatal period in such cases. Patients who reach the hospital are often not stable enough to permit an MRI

examination that can last between 25 minutes to 45 minutes. In this study, we have tried to analyze the pattern of neuroimaging findings in patients sent for MRI with a history of alleged attempted suicidal hanging between June 2020 and June 2023.

Patients and Methods

This study was a retrospective, longitudinal, single-center study of all patients admitted for alleged attempted suicidal hanging to any department at North Bengal Medical College and Hospital which is a tertiary care center in North Eastern India with 1000 plus bed capacity. The study was started after obtaining clearance from the Institutional Ethics Committee. Patients who were sent for MRI imaging of the brain and spinal cord between June 2020 and June 2023 were included in the study. Inclusion criteria were age more than 18 years and admission with a history of alleged hanging. Exclusion criteria included patients less than 18 years and patients whose relatives did not consent to the study. In total, 74 patients, who had received an emergency MRI were selected from the medical record database of the hospital after applying the inclusion

and exclusion criteria. The MRI requisition along with the medical reports and case history of every case was manually screened by one clinician to check whether the defined inclusion criterion of alleged attempted suicidal hanging was fulfilled. No consent was required from the studied cases since they've lost their autonomy by their suicidal attempts however we still asked for consent from the relatives of the patients as the topic under study was extremely sensitive and had a medicolegal implication.

Relatives of patients who had refused, or revoked general consent were excluded from the study. Following the collection of eligible cases, one Radiologist with over 25 years of experience in radiology and currently a Professor and the Head of the Department of Radiology in the institute reviewed the images for, parenchymal abnormal signal changes, signs of dissection of the cervical vessels, bones and soft tissues, and spinal cord signal changes. The initial reports on the retrospectively analyzed patients were written by a senior resident in Radio-diagnosis. The MRI machine used in the institute was a 1.5 Tesla scanner (SIGNA™ 1.5T MRI scanners GE Healthcare, Cambridge, UK, Manufacturing date – 2011). The images were obtained as per institutional protocol and included Diffusion Weighted Images(DWI) a diffusion weighting factor $b = 1000 \text{ s/mm}^2$ plus one reference scan with $b = 0$, Apparent Diffusion Coefficient(ADC) maps with manually outlined predefined regions of interest in the cortex and basal ganglia, Axial T2 Weighted Images(T2WI), Axial Fluid-attenuated inversion recovery(FLAIR) Images and Saggital T1Weighted Images(T1WI). The section thickness was 5 mm and the section gap was 1 mm for the images. Imaging was done from the vertex upto C7 cervical vertebrae

Ethics

Approval was taken from the Institutional ethical committee. Ethical standards were followed as per the Declaration of Helsinki

Results

A total of 74 patients were included in the study. Of them 34 were male and 40 were female. The mean age was 28.40 years (range 18-52 years). Most of the patients belonged to the age group of 20-30 years (43.24%) and the least belonged to over 50 years (5.4%). Studied cases in this 20-30 years age group were

predominantly males (56.25%). Figure (1) demonstrates the age and sex distribution of the study population. Hanging was considered complete when there was total suspension of the body off the ground with the

Hanging was considered complete when the patient's legs were fully suspended off the ground and the patient's body weight was fully suspended by the neck. Incomplete hanging was considered when some part of the patient's body was still on the ground and the body's full weight was not suspended off the ground. We collected this data from the history sheet of the patients on the admission file of the hospital which is attached with the MRI request as per institutional policy. This data is collected by the treating physicians from the patient's relatives and the primary police inquest report during the admission process as per prevailing law of the country. In the majority of the cases, the hanging was complete(59.45%) and in the rest, the hanging was incomplete type(40.54%) Among the studied patients, neuroimaging abnormality was present only among 29.72% of the population. On neuroimaging the predominant finding was a normal study among 70.27%. The neuroimaging findings in the study population are shown in Figure 2. Among those with an abnormal neuroimaging study (29.72%), the predominant finding was that of adult-type hypoxic-ischemic encephalopathy (HIE) in 45.45% of cases. Figure 3 shows a case with adult-type HIE findings on MRI. The least common injury seen was bony injury seen in 9% of the patients. Vascular injury was seen in 18.18% of cases. 1 case had a fracture of the greater cornu of the hyoid bone and 1 case had injuries of the cervical spine. Among vascular injuries, the most common injury was a dissection of the common carotid artery with equal incidence on the right and left sides. Spinal cord injury manifested as T2 hyperintensity in the spinal cord as seen in 18.18% of cases (Figure 4). Abnormal neuroimaging findings were more common among female patients (54.54%). Figure 5 demonstrates the areas of diffusion restriction and hyperintense signal on T2WI and FLAIR images in MRI among these patients with positive brain parenchymal imaging findings. All cases which had positive imaging findings had neck soft tissue and muscle edema on MRI along with 18 cases that had no neuroimaging abnormality on MRI.

Table (1): Distribution of the study population according to age, sex, type of hanging and neuroimaging findings

	Sex				Type of hanging				Neuroimaging findings			
	Male		Female		Complete		Incomplete		Present		Not present	
Age	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
<20	4	11.8	12	30.0	10	22.7	6	20	2	9.1	14	26.9
20-30	18	52.9	14	35.0	26	59.1	6	20	11	50.0	21	40.5
31-40	8	23.5	6	15.0	3	6.8	11	36.6	5	22.7	9	17.3
41-50	2	5.9	6	15.0	4	9.1	4	13.3	2	9.1	6	11.5
>50	2	5.9	2	5.0	1	2.3	3	10	2	9.1	2	3.8
Total	34	10	40	100	44	100	30	100	22	100	52	100

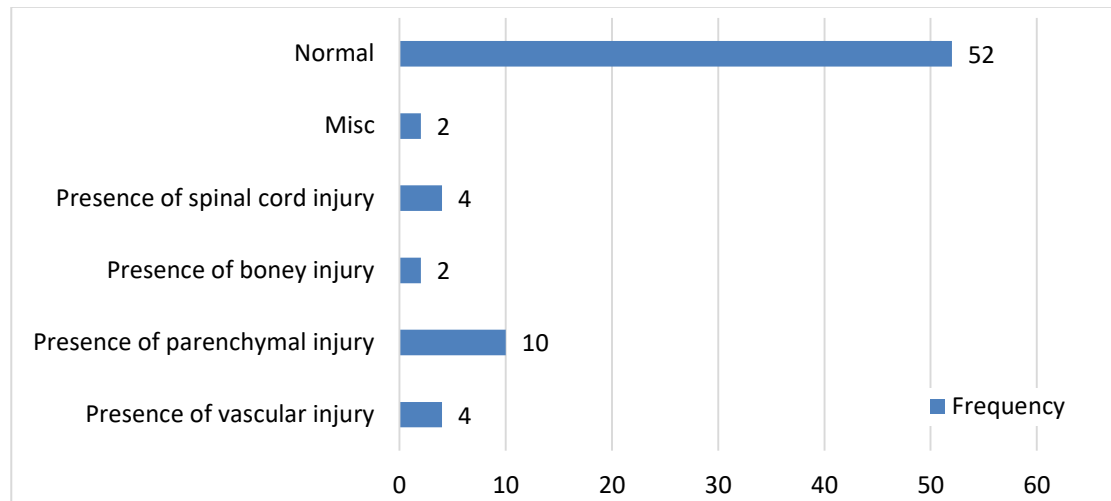


Figure (1) – Neuroimaging findings among the study population

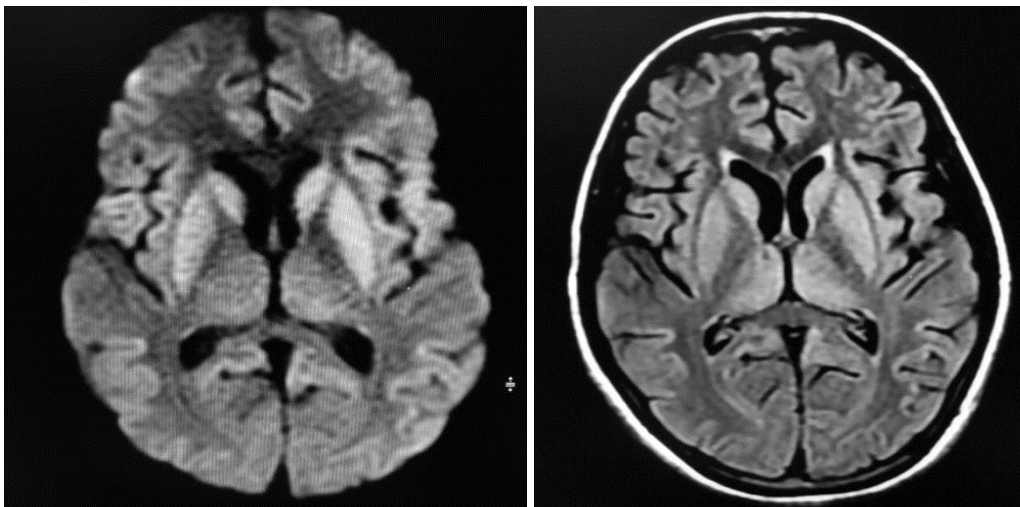


Figure (2) -Diffusion restriction in both cerebral hemispheres in frontal, parietal occipital cortex along with diffusion restriction in the bilateral caudate nucleus, lentiform nucleus, and thalamus region with corresponding areas of hyperintensities on FLAIR.



Figure (3)– T2 weighted sagittal image of the cervical spine showing hyperintensity in spinal cord opposite to the third and fourth cervical vertebrae

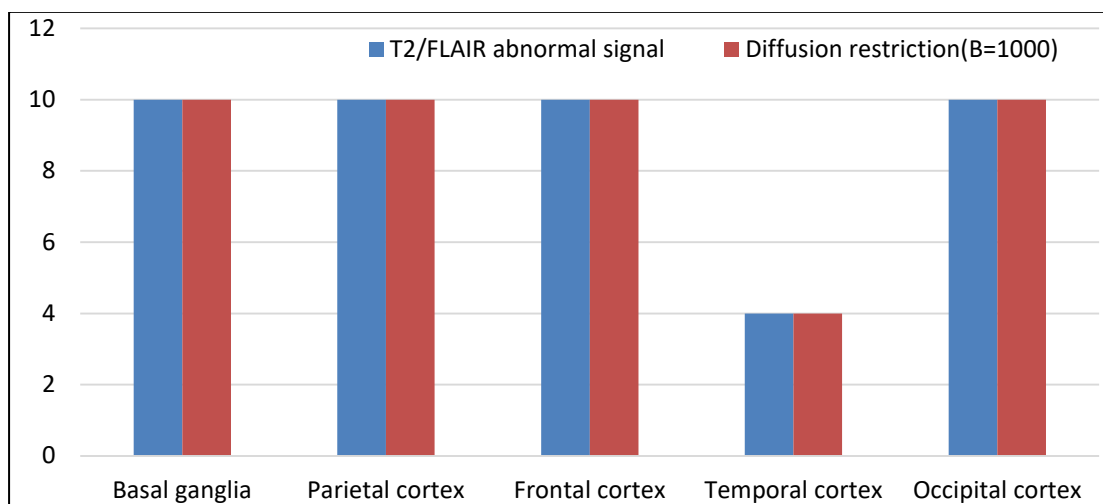


Figure (4)– The location-wise distribution of abnormal signal changes in the brain parenchyma

Discussion

Hanging (self-suspension) is a form of asphyxia that is caused by the suspension of the body by a ligature that encircles the neck, the constricting force being the weight of the body (Reddy and Murthy, 2014). Hanging is a common mode of suicide and is also used as capital punishment in some countries. Hanging is defined as complete when the entire body is in suspension and partial when some part of the body touches the ground. It is also classified as typical and atypical based on the position of the knot of ligature with typical hanging having the knot at the nape of the neck and atypical hanging having the ligature anywhere else. The rate of suicide is increasing in India. A total of 1,39,123 suicides were reported in the country during 2019 showing an increase of 3.4% in comparison to 2018 and the rate of suicides has increased by 0.2% during 2019 over 2018. Hanging was the most commonly used method accounting for 53.6% (Radhakrishnan and Andrade, 2012). In hanging, death generally occurs due to a combination of asphyxia and cerebral anemia. Patients who survive near-fatal hanging are often left with residual neurological damage depending on the part of the cortex or spinal cord involved. The common ones include permanent hypoxic brain damage, paraplegia, aphasia, agnosia, limb rigidity, and gait abnormality. Uncommon ones include dissection of the carotid and vertebral arteries, posterior reversible encephalopathy syndrome, hyperthermia, retrograde or antegrade amnesia of the event and Korsakoff's psychosis.

Sometimes there are large gaps between the suicide attempt and death, even in the absence of neurological abnormalities. Vascular obstruction, vagal stimulation, carotid sinus pressure, or a combination of these also seem to play a role in the death

Nagar and Bastia, (2022) found the rate of suicide by hanging was higher in males than females with the ratio of men to women is 3.33:1. The mean ages of the males and females were 33.09 ± 12.59 and 24.9 ± 7.84 years, respectively. Llic and Ilic, (2022) found the ratio to be 2.6:1. This was in disagreement with our study where we found the ratio to be 0.85:1.

The most likely explanation for this is the fact that both the studies mentioned above considered only fatal cases of suicide by hanging and not cases of attempted hanging. This is further supported by the fact that one recently conducted study in this regard found that females outnumbered males at a ratio of 3.7 to 1 in cases of suicide attempters and the greatest proportion of cases was in the age group of 21 to 30 years (52.9%) which was consistent with findings of our case where it constituted 43.24% (Zhao et al., 2015).

Ramdurg et al, (2011) found the male-to-female ratio to be similar in their study on patients who attempted suicidal hanging. The mean age at the time of suicide attempts in that study was 31.5 years (SD 11.62), with a range of 16-64 years. A total of 33% of cases belonged to the age group of 20 to 30 years. Gunnell et al., (2005) found that case fatality following attempted suicide by hanging is around 70% and the majority (80-90%) of those who reach the hospital alive survive (Gunnell et al., 2005; Zhao et al.,2015). Similar findings were also reported by Heimer et al., (2023) who concluded that most cases of non-fatal hanging lead to no or minor injuries if any. This was consistent with our findings as 70.27% of our study population did not show any neuroimaging changes

The pathophysiological changes in cases of hanging have been described to include focal cavitory lesions in the caudate, putamen, and globus pallidus bilaterally. Multiple studies have shown the CT changes in hanging patients as hypodensities in the above-mentioned areas. Similar findings are also seen in patients with carbon monoxide poisoning, methanol toxicity, drowning, and global cerebral hypoxia. The likely explanation for this phenomenon is that these areas are more metabolically active than the rest of the cerebrum but are not as well perfused because they lie in the boundary zone of cerebral perfusion. Any acute insult causing cerebral hypoxia is hence precipitated in these regions. Hence a similar mechanism can be postulated for hanging and presumably for other conditions that are known to produce acute cerebral hypoxia (Binaco and Floris, 1987). The characteristic

MRI findings in the case of acute global cerebral ischemia have been described by many authors and textbooks. The findings have been described as hyperintensity on the basal ganglia and thalami in both T1 and T2 weighted images. It was postulated that these specific findings reflected tissue degeneration, deposition of mineral substances, or lipid accumulation. These findings may indicate tissue degeneration, deposition of mineral substances, or lipid accumulation

There are only a handful of reports of MRI findings in patients who attempted suicide by hanging. The reason is that most of these patients usually die due to a narrow fatal period of 3 to 5 minutes before they reach the hospital (Reddy and Murthy, 2014). Among those who reach the hospital the general condition of these patients doesn't allow for an MRI examination which is a long time-consuming process and most physicians have to rely on X-rays cervical spine and CT.

Jawaid et al., (2017) reported cerebral edema in 33.7% of patients and posterior reversible encephalopathy syndrome in 1 patient.5 among 19 patients who underwent an MRI had changes of HIE. In our study, changes of HIE were present in 13.51% of patients

Matsuyama et al., (2006) reported MRI brain findings in a hanging patient. MRI demonstrated symmetrical hyperintensity on T1WI and hyperintensity on T2WI in bilateral lentiform nuclei and medial thalami. Garaci et al., (2009) reported in a patient a hyperintense area on T2WI in the right ventromedial thalamic nuclei without diffusion restriction in the territory of thalamoperforating branches of the posterior cerebral artery suggesting cryptogenic stroke. Nakajo et al., (2003) reported in a survivor of hanging presence of both hemorrhagic and ischemic lesions concurrently. Ischemic lesions in the capsuloganglionic region along with evidence of subarachnoid hemorrhage. Kalita et al., (2002) in a case series with three females who attempted suicide by hanging found that MRI revealed hyperintense signal changes in the globus pallidus, caudate nucleus, and thalamus in all patients and the midbrain in one patient. Yadav et al., (2009) described a case of suicidal hanging with atlantoaxial dislocation without any fracture on X-ray, CT, and autopsy. Choi et al., (2019) found among hanging survivors decreased ADC values represented areas of restricted diffusion, because of infarction. Only 3 of the 14 patients in whom ADC value was measured had a favorable outcome. The thalamus showed the lowest mean ADC value while the temporal cortex had the highest mean ADC value. Restricted diffusion was evident in the frontal, parietal, temporal, occipital, thalamus, caudate nucleus, putamen, hippocampus, pons, putamen, and cerebellum. They also concluded that low ADC values in the cortex and deep grey nuclei on DWI performed within 3 hours after hanging well-correlated with unfavorable outcomes. In our study, we found restricted diffusion and T2/FLAIR hyperintense signals in the frontal, parietal, and temporal cortex among all

the cases with parenchymal neuroimaging changes. However, only 4 out of the 10 cases had temporal parenchymal neuroimaging changes.

Jawaid et al., (2017) reported cervical spine injury in 2.9% of cases. Heimer et al., (2023) found soft tissue injury in 34.1% of cases, vascular injuries among 0.8%, and intracranial pathology in 14.6% of cases. In our study, we found bony injury among 2.7% of cases mainly involving the hyoid bone and involving the cervical spine. Soft tissue edema was seen among all patients with abnormal neuroimaging findings and among 18 cases without neuroimaging abnormality. This accounted for 54.05% of the study patients vascular injury was seen in 5.4% of cases and was related to carotid artery dissection and spinal cord injury was also seen in another 5.4% of the cases.

Conclusion

Hanging is a common mode of suicide where the fatal period is very narrow. Death occurs due to a combination of asphyxia and cerebral anemia. Most cases of non-fatal hanging do not show any pathological findings on MRI. The most common pathological neuroimaging findings in hanging patients are predominantly reflective of acute global hypoxic injury. However rare findings can also be seen like spinal cord injuries and vascular dissection. Further investigation and large-scale studies are needed in this regard which might help us better understand the pathophysiology of the condition

References

- Bianco F. and Floris R. (1987). Computed tomography abnormalities in hanging. *Neuroradiology*, 29(3), pp.297–298. doi:<https://doi.org/10.1007/bf00451772>. PMID: 3614628
- Brancatelli, G., Sparacia, G., Midiri, M. et al. (2000). Brain damage in hanging: a new CT finding. *Neuroradiology* 42, 209–210. <https://doi.org/10.1007/s002340050048>
- Choi, D., Lee, S., Jeong, S.-H., Jung Tak Park and Kim, H. (2019). Early diffusion-weighted imaging and outcome prediction of comatose survivors after suicidal hanging. 37(1), pp.5–11. doi:<https://doi.org/10.1016/j.ajem.2018.04.027>.
- Garaci, F., Bazzocchi, G., Luca Velari, Gaudiello, F., Goldstein, A., Guglielmo Manenti, Floris, R. and Simonetti, G. (2009). Cryptogenic Stroke in Hanging. *The Neuroradiology Journal*, 22(4), pp.386–390. doi: <https://doi.org/10.1177/197140090902200404>.
- Gunnell D, Bennewith O, Hawton K, Simkin S, Kapur N. (2005). The epidemiology and prevention of suicide by hanging: a systematic review. *International Journal of Epidemiology*. 19;34 (2): 433–42.
- Heimer J, Arneberg L, Blunier S, Jolanta Klukowska-Rötzler, Gonzenbach AG, Exadaktylos AK, Ruder T, Wagner F, (2023). Under-reporting of forensic findings: craniocervical emergency imaging in cases of survived hanging. *Forensic*

- Science, Medicine and Pathology; <https://doi.org/10.1007/s12024-023-00665-8>.
- Ilic, M. and Ilic, I. (2022) 'Trends in suicide by hanging, strangulation, and suffocation in Serbia, 1991-2020: A joinpoint regression and age-period-cohort analysis', *World Journal of Psychiatry*, 12(3), pp. 505–520. Available at: <https://doi.org/10.5498/wjp.v12.i3.505>.
- Jawaid, M, Amalnath, Sd., and Subrahmanyam, D.K.S. (2017) 'Neurological outcomes following suicidal hanging: A prospective study of 101 patients', *Annals of Indian Academy of Matsuyama, T., Okuchi, K., Seki, T., Higuchi, T., Ito, S., Makita, D., Watanabe, T. and Murao, Y. (2006). Magnetic resonance images in hanging. Resuscitation*, 69(2), pp.343–345. doi: <https://doi.org/10.1016/j.resuscitation.2005.08.03>.
- Kalita, J., Mishra, V.N., Misra, U.K. and Gupta, R.K. (2002). Clinicroadiological observation in three patients with suicidal hanging. *Journal of the Neurological Sciences*, 198(1-2), pp.21–24. doi: [https://doi.org/10.1016/s0022-510x\(02\)00056-4](https://doi.org/10.1016/s0022-510x(02)00056-4).
- Matsuyama T, Okuchi K, Seki T, Higuchi T, Ito S, Makita D, Watanabe T, Murao Y, (2006) Magnetic resonance images in hanging, *Resuscitation*, 69(2):343-345, <https://doi.org/10.1016/j.resuscitation.2005.08.03>.
- Nagar, N. and Bastia, B.K. (2022) 'The Demographic Profile of Suicidal Hanging Deaths in North India', *Cureus [Preprint]*. Available at: <https://doi.org/10.7759/cureus.30409>.
- Nakajo M, Onohara S, Shinmura K, Nakajo M, Amitani H, Munamoto T and Baba, Y. (2003). Computed Tomography and Magnetic Resonance Imaging Findings of Brain Damage by Hanging. *Journal of Computer Assisted Tomography*, 27(6), pp.896–900. doi: <https://doi.org/10.1097/00004728-200311000-00011>.
- Radhakrishnan, R. and Andrade, C. (2012) 'Suicide: An Indian perspective', *Indian Journal of Psychiatry*, 54(4), p. 304. Available at: <https://doi.org/10.4103/0019-5545.104793>.
- Ramdurg S, Goyal P, Sharan P, Goyal S, Sagar R. (2012). Sociodemographic profile, clinical factors, and mode of attempt in suicide attempters in consultation liaison psychiatry in a tertiary care center. *Industrial Psychiatry Journal* ;20(1):11.
- Reddy NKS and Murty OP. (2014). *The essentials of forensic medicine and toxicology*. 33rd edition. New Delhi: Jaypee Brothers Medical Publishers.
- Yadav A, Gupta B.M, Deepali P. (2009). Atlanto-axial dislocation in suicidal hanging, a rare outcome. 9. 12-13.
- Zhao, C., Dang, X., Su, X., Bai, J. and Ma, L. (2015). Epidemiology of Suicide and Associated Socio-Demographic Factors in Emergency Department Patients in 7 General Hospitals in Northwestern China. *Medical Science Monitor*, 21, pp.2743–2749. doi: <https://doi.org/10.12659/msm.894819>.

نتائج التصوير العصبي بالرنين المغناطيسي لدى المرضى الهنود الذين نجوا من الشنق الانتحاري دراسة بأثر رجعي

أودالوك داس^١ و جاغاديش بيسواس و نارايان بانديت^١ و تريبارنا بادرا

الملخص العربي

الخلفية: الشنق هو وسيلة شائعة للانتحار. في كل عام، ينتحر أكثر من ١٠٠٠٠٠ شخص في بلادنا. على الرغم من وجود عدد قليل من الدراسات التي تصف نتائج التصوير المقطعي المحوسب (CT) للمحور العصبي في حالات الشنق، فإن الدراسات التي تصف نتائج التصوير بالرنين المغناطيسي (MRI) ليست سوى حفنة قليلة. والسبب هو أن معظم هؤلاء المرضى يموتون عادة بسبب فترة قاتلة ضيقة تتراوح من ٣ إلى ٥ دقائق قبل وصولهم إلى المستشفى. ومن بين الذين يصلون إلى المستشفى، الحالة العامة السيئة لا تسمح بالوقت الطويل اللازم لإجراء التصوير بالرنين المغناطيسي. **الطريقة:** تم إجراء دراسة بأثر رجعي حيث تم تحليل نتائج التصوير العصبي في التصوير بالرنين المغناطيسي لدى المرضى المحالين من أقسام مختلفة والذين لديهم تاريخ في الشنق بين يونيو ٢٠٢٠ إلى يونيو ٢٠٢٣. **النتائج:** شملت الدراسة ٧٤ حالة شنق غير مميتة، مع ٢٩.٧٢٪ فقط من الحالات تظهر تشوهات في التصوير العصبي (NIA). كان الاعتلال الدماغى الإقفارى بنقص التأكسج من النوع البالغ هو أكثر حالات الاعتلال الدماغى غير المتوقعة شيوعاً (١٣.٥١٪)، مع إصابة الفص الجبهى الجدارى القذالى بنسبة ١٠٠٪ وإصابة الفص الصدغى في ٤٠٪ من الحالات. شوهدت إصابة الحبل الشوكى التي تظهر على شكل فرط كثافة إشارة الحبل بين ١٨.١٨٪ من مجتمع الدراسة. وشملت النتائج المتنوعة الأخرى إصابات الأوعية الدموية والعظمية والنخاع الشوكى وعضلات الرقبة في ١٨.١٨٪ و ٩٪ و ٣٧.٨٤٪ من الحالات على التوالي. **الاستنتاج:** معظم حالات الشنق غير المميتة لا تظهر أي نيا مرضية. من بين المصابين بـ NIA، تعكس النتائج في الغالب الإصابة العالمية الحادة بنقص الأكسجة. هناك حاجة إلى مزيد من التحقيقات والدراسات واسعة النطاق لفهم الفيزيولوجيا المرضية للحالة بشكل أفضل والتنبؤ هؤلاء المرضى بناءً على نتائج التصوير العصبي.

١. قسم الأشعة التشخيصية مستشفى وكلية شمال بنغال الطبية- الهند

٢. قسم الطب الشرعى والسموم كلية ومستشفى بنغال الشمالية- الهند

٣. قسم الباطنة العامة -كلية ومستشفى بنغال الشمالية- الهند