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Hypoxic Brain Changes in Victims Who Died Due to Hanging- An Autopsy Based Study

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Abstract

Survival after attempted hanging is a rare event. Many patients who suffer from hypoxic brain damage following hanging die immediately. The study was conducted in the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram during the period January 2013 to June 2014. 50 cases were included in the study. Among the 50 cases, 25 cases were the hanging cases that survived for varying periods before death and 25 cases were from the non-survived victims of hanging. Macroscopic and microscopic changes in the brain, were compared to find out the changes resulting from hypoxic insult. The cases were studied in detail and are described below.

Keywords: Hanging, Hypoxic brain changes, Survival after hanging

Introduction

Hanging is an easy and highly effective method of committing suicide with a high mortality rate. According to World Health Organization, hanging was the predominant method of suicide in 56 countries included in their analysis[1]. As per Indian National crime records bureau report of 2012, it had been found that death by hanging was 37% in 2012[2]. The departmental statistics of the Department of Forensic Medicine, State Medico-legal institute of Kerala, Government Medical College, Thiruvanathapuram for the past 6 years (from 2007 to 2012) had shown that around 22 to 29% of deaths among the total medico-legal postmortems conducted per year were due to hanging. 15 to 16% of cases of total hanging cases were brought down alive during hanging but died before getting any treatment and only 1 to 2% survived to reach a hospital. Hence survival after hanging is a rare event. A long survival and recovery is rarer.

The present study was an attempt to compare the macroscopic and microscopic changes in the brain of non-survived victims and victims who survived for variable periods before death.

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Materials and Methods

The study was conducted in the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram during the period January 2013 to June 2014. 50 cases were included in the study. Victims of both sexes were included in the study and their age range was between 13 and 88 years. Cases were divided into two groups. Group I included 25 cases of non-survived victims of hanging Group II consisted of 25 cases of hanging that survived for varying periods before death. History and other details were collected from the police officer in charge of the concerned dead body, accompanying near relative and from clinical case records. Dissections were carried out by Modified Rokitansky procedure. During autopsy, the macroscopic appearances of the brain was recorded in the proforma. Bits of tissues were taken from brain (from regions of hippocampus, basal ganglia, midbrain and cerebellum using a sharp knife. Tissues were fixed in 10% formalin, processed and stained with Harris Hematoxylin and Eosin stains. The slides were labeled according to serial number. Microscopic examination of each slide was done in various powers and the details were noted in the proforma. Gross and histological findings of brain were compared and data were analysed using SPSS (Statistical Package for Social Sciences) version 16.

Observations And Results

Macroscopic And Microscopic Findings In The Brain

A. Macroscopic Appearances

1. **Weight Of Brain**

   Weight of the brain was recorded in all cases. In Group I (non-survived group), the maximum weight of brain was 1300g, minimum weight was 1100 g and mean weight was 1188g with a standard deviation of 58g. The maximum weight of brain in Group II (survived group) was 1300 g and minimum weight was 1100 g. The mean weight of the brain was 1206 g with a standard deviation of 58 g.

2. **Congestion And Edema**

   Congestion and edema of the brain were seen in all the cases of Group I (non-survived group) and II (survived group)

3. **Sub Arachnoid Hemorrhage**

   Subarachnoid hemorrhage was present in only one case of Group II (survived group) who survived for more than 12 hours. This finding was not seen in all other cases of Group II (survived group) and Group I (non-survived group)

4. **Softening of Hippocampus, Basal Ganglia and Cerebellum**

   Softening of hippocampus, basal ganglia and cerebellum were present in 52% of cases in Group II (survived group) victims who had survived for more than 12 hours. It was absent in other cases in Group II (survived group) and all cases in Group I.

B. Microscopic Appearances

Microscopic examination of the brain tissue from hippocampus, basal ganglia, brain stem and cerebellum were studied.

1. Congestion and Edema

Congestion and edema of hippocampus, basal ganglia and brain stem were seen in all cases of Group I and II. (non-survived and survived groups)

2. Red Neurons

Red neurons in the hippocampus were present in the 40% of cases in Group II (survived group) who had a survival period of more than 12 hours and it was not seen in the remaining 60% cases of Group II (survived group) and all cases of Group I (non-survived group).

Red neurons in the basal ganglia were present in 32% of cases in Group II (survived group) who had survived for more than 24 hours.

3. Vacuoles in Neuronal Cytoplasm

Vacuoles in the neuronal cytoplasm of hippocampus was present in one case of Group II (survived group) who had survived for a period of less than one hour. It was absent in the remaining cases of Group II (survived group) and all cases of Group I (non-survived group)

4. Karyolysis of Purkinje Cells of Cerebellum

Karyolysis of Purkinje cells of cerebellum was present only in one case of Group II (survived group) who had survived for more than 24 hours. This finding was absent in the remaining cases of Group II (survived group) and all cases of Group I (non-survived group).

Macroscopic Changes in the Brain with Progression of Survival Time

Table 1: Macroscopic changes in the brain with progression of survival time

Period of Survival	No	Congestion	Edema	Softening of Hippocampus Basal ganglia Cerebellum	Subarachnoid Hemorrhage
Less than 1 hour	4	4	4		
1-3 hours	5	5	5		
3-6 hours	3	3	3		
6-12 hours	1	1	1	1	
12-24 hours	4	4	4	4	1
1-2 days	1	1	1	1	
2-3 days	1	1	1	1	
3-7 days	5	5	5	5	
7-12 days	1	1	1	1	

Microscopic Changes in the Brain With Progression of Survival Time

Table 2: Microscopic changes in the brain with progression of survival time

Period of survival	No	Congestion			Edema			Red neurons		Vacuole	Karyolysis
		HC	BG	BS	HC	BG	BS	HC	BG	HC	Cerebellum
Less than 1 hour	4	4	4	4	4	4	4			1	
1-3 hours	5	5	5	5	5	5	5				
3-6 hours	3	3	3	3	3	3	3				
6-12 hours	1	1	1	1	1	1	1				
12-24 hours	4	4	4	4	4	4	4	2			
1-2 days	1	1	1	1	1	1	1	1	1		1
2-3 days	1	1	1	1	1	1	1	1	1		
3-7 days	5	5	5	5	5	5	5	5	5		
7-12days	1	1	1	1	1	1	1	1	1		

Histopathological findings found significant in bivariate analysis

Period of survival and microscopic findings in the brain, heart and lungs were studied using Chi Square test with n-1 degrees of freedom. Softening of hippocampus, basal ganglia and cerebellum and the presence of red neurons in the hippocampus and basal ganglia has a significant relationship with period of survival. These findings are commonly seen in the victims who survived for a long time. These findings were either absent or present in a small group in the non-survived group.

Table 3: Histopathological findings in brain found significant in bivariate analysis

Factors	Category	Group I (non-survived group) n=25	Group II (survived group) n=25	P value
Softening of hippocampus, basal ganglia and cerebellum	Present	0	13	<0.001
	Absent	25	12	
Red neurons in hippocampus	Present	0	10	<0.001
	Absent	25	15	
Red neurons in basal ganglia	Present	0	8	0.002
	Absent	25	17	

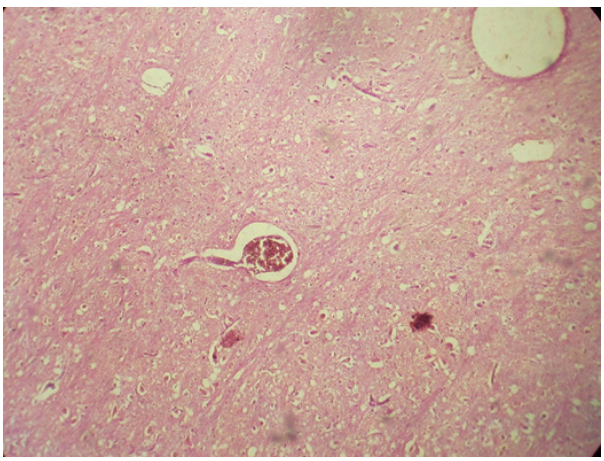

Fig 1: Congestion and edema in hippocampus H&E, x 100

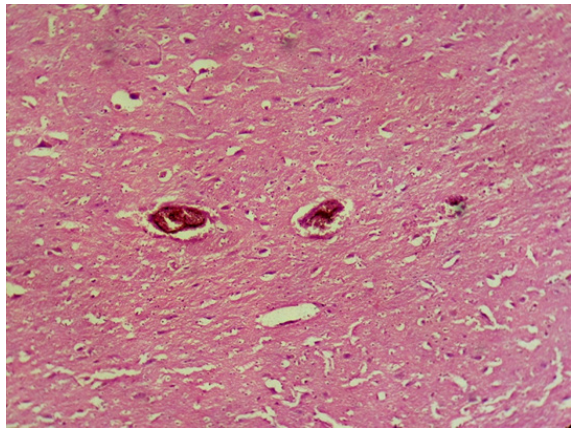

Fig 2: Congestion and edema in basal ganglia, H&E x100

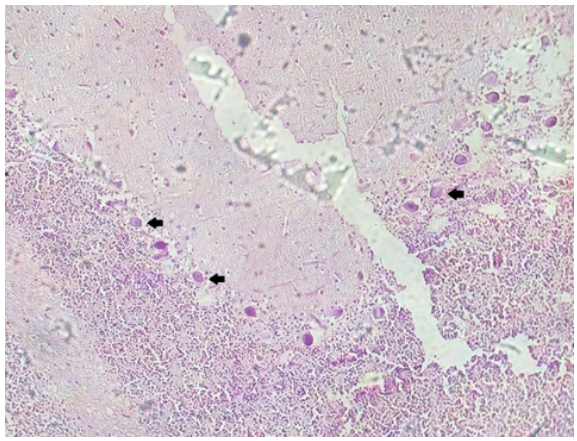

Fig 3: Red neurons in hippocampus H&E x 400

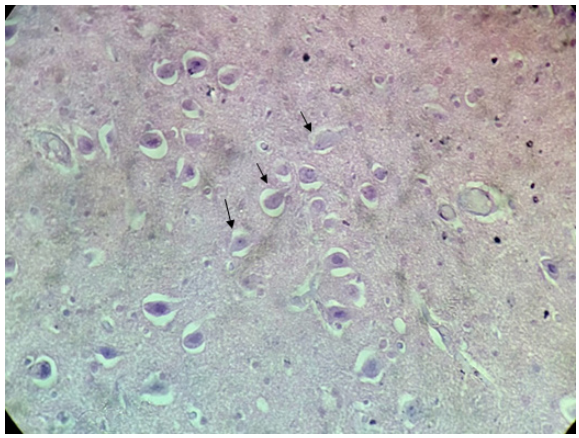

Fig 4: Karyolysis of Purkinje cells of cerebellum H&E x 400

Discussion

Macroscopic And Microscopic Findings in Brain

a. Macroscopic appearances

1. **Congestion** of the brain was seen in all the cases of Group I (non-survived group) and II (survived group) macroscopically. Microscopically congestion was seen in all the regions. Congestion has been described as a cardinal feature of asphyxia. Congestion of brain as a macroscopic autopsy finding in non-survived victims of hanging have been described by various authors[3,4,5,6] and according to them, congestion occurs due to compression of jugular venous system where the carotid flow remains intact. In Group II (survived group), congestion of the brain was a constant finding from less than one hour survival period to 12 days of survival. This was one of the first changes noted in the present study in both groups. Hence congestion could have been the first change in the brain which occurs following cerebral venous congestion.

2. **Brain edema** was another finding seen in all the cases of Group I (non-survived group) and II (survived group) macroscopically and could be demonstrated microscopically. Brain edema had not been described by any of the studies in non-survived victims of hanging. In Group II (survived group), edema of the brain was a constant finding from less than one hour survival period to 12 days of survival. According to one author, cerebral edema becomes apparent both clinically and histologically only 1 to 4 hours after severe hypoxic insult, however in the present study it was seen in victims who survived for less than one-hour also[7]. Brain edema in attempted hanging and strangulation victims had been described by various authors[8,9,10,11,12]. In another study of CT brain imaging done in 43 cases of attempted hanging reported brain edema in 32%.[13]. But brain edema was seen in all cases of the present study. Hence, we could assume that when there is congestion, edema will follow.

3. **Softening of hippocampus, basal ganglia and cerebellum** were present in 52% of cases in Group II (survived group). This was seen in victims who survived at least for 6 hours up to 12 days. Scalloped pattern of cortex at places, and atrophy of cerebellar folia following hypoxic insult has been described[6]. This might have been consistent with softening appreciated in the areas of brain in the present study. Certain areas of the brain are selectively vulnerable to hypoxia like the hippocampus, basal ganglia and cerebellum[14]. Though they had described characteristic microscopic changes in these areas, they had not mentioned any macroscopic changes, however softening of hippocampus, basal ganglia and cerebellum noted was in the present study.

4. **Subarachnoid hemorrhage** was present in only one case of Group II (survived group) who had a survival period of 12 to 24 hours. Subarachnoid effusions are common in hanging victims according to Reddy, however the author has not mentioned sub arachnoid hemorrhage specifically[15].

b. Other microscopic appearances

1. **Red neuron** is a neuron which becomes shrunken, its triangular shape intensified, its nucleus becomes pyknotic, and its cytoplasm takes on abnormal intense eosinophilic staining property following hypoxic insult. Such types of neurons were present in the hippocampus and basal ganglia of victims of hanging who survived for varying periods before death (Group II (survived group)). They were seen in the hippocampus of 40% of cases who had a survival period of more than 12 hours and in the basal ganglia of 32% of cases who had survived more than 24 hours. Red neurons were seen in the hippocampus from 12 hours to 12 days of survival. Among the four cases who survived for 12 to 24 hours only two cases had showed red neurons but from 24 to 48 hours of survival, all cases had shown the finding. Red neurons were seen in the basal ganglia in all cases who survived for more than 24 hours. Such neurons were not seen in the midbrain or cerebellum. Red neurons first appear 12 to 24 hours after the hypoxic insult[16]. This is in agreement with the present study. Red neurons were not seen in the non-survived victims but could be seen in the survived victims beyond 12 hours of survival. Its appearance is directly proportional to survival time.

2. **Vacuoles in neuronal cytoplasm** of hippocampus were present in only one case of Group II (survived group) who had a survival period of less than one hour. Vacuoles which are seen in the cytoplasm of neurons occur due to autolytic changes and therefore they should be considered as an insignificant finding[14].

3. **Karyolysis of Purkinje cells** of cerebellum was present only in one case of Group II (survived group) who had survived for 24 to 36 hours. Purkinje cells of the cerebellum are selectively vulnerable to hypoxia[14]. Purkinje cells shows a homogenising cell change, the cytoplasm becomes progressively paler and homogenous and nucleus becomes smaller.[14,17] The findings in the present study are in agreement with the above-mentioned studies. Atrophy of cerebral cortex seen on autopsy has been described.[6] Early reactive changes are seen in the microglia and endothelial cells when the person survives for more than 24 hours[14,17].

Conclusion

The study was conducted in the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram during the period January 2013 to June 2014. Fifty cases were included in the study, twenty-five cases were from the non-survived victims of hanging (Grouped as I) and twenty five cases were from the hanging cases that survived for varying periods before death (Grouped as II. The following findings were observed

Congestion had been described as a cardinal sign of asphyxia. Congestion of the brain was seen in all the cases of both non survived and survived groups macroscopically and microscopically. Brain edema was another finding seen in all the cases of Group I and II macroscopically and could be demonstrated microscopically. We could assume that when there is an association between congestion and brain edema. When there is congestion, of brain, edema also could be there. Softening of hippocampus, basal ganglia and cerebellum were present in 52% of cases in Survived group. This was seen in victims who survived at least for 6 hours and upto 12 days. This change was seen with progression of survival time. This might have been due to the hypoxia persisting with diminished perfusion. This finding was not seen in the non-survived group. Red neurons were seen in the hippocampus of cases who had a survival period of more than 12 hours and in the basal ganglia of cases who had survived more than 24 hours. Red neurons were not seen in the non-survived victims. Its appearance is directly proportional to survival time. Karyolysis of Purkinje cells of cerebellum were present only in one case of survived group who had a survival period more than 24 hours. This might have been due to the selective vulnerability of cerebellum to hypoxic insult.

Survival after attempted hanging is a rare event. Many patients who suffer from hypoxic brain damage following hanging die immediately. Histopathological examination of bits of tissue from the hippocampus, basal ganglia, brain stem, cerebellum, should suffice to establish that the victim has experienced an episode of hypoxia sufficiently severe to produce wide spread damage to this brain. This study has established that hanging produces hypoxic damage to the the brain.

Conflict of Intrest: We hereby declare that there is no conflict of interest

Source of Funding: Self

Ethical Clearance: Ethical Clearance Had Been Obtained From Institutional Ethical Committee Of Government Medical College, Thiruvanathapuram.

References

1. Vladeta Ajdacic- Gross et al. Methods of suicide: international suicide patterns derived from the WHO mortality database. Bulletin of World Health Organization 2008:86:726-732.
2. National Crime Records Bureau Report 2012, Ministry of Home Affairs, Govt Of India.
3. Kannan K, Mathiharan K. MODI A Textbook of Medical Jurisprudence and Toxicology.24thed.New Delhi: Butterworths; 2012. P.445-50.
4. Karmakar R.N.J.B Mukherjee's Forensic Medicine and Toxicology.4th ed. Kolkota. Academic Publishers.P.499-523.
5. Bardale R. Principles of Forensic Medicine & Toxicology. New Delhi: Jaypee; 2011.P.284-95
6. Guhraj PV, Chandran MR. Forensic Medicine.2nd ed. Hyderabad: Universities Press(India) Pvt Ltd;2009.P.175-79

7. Meldrum B.S Neuropathology and Neurophysiology. A textbook of epilepsy. Edinburgh: Churchil Livingstone;1976.

8. Vaghela D.R. late death in a case of hanging, a case report. Internet Journal of Forensic Medicine & Toxicology; 2009 Jan ;1.10(1).

9. Zivkovic V, Nikolic S. Near- hanging with outliving period: patho forensic aspects. Srp Arh Celok Lek. 2012 Mar- Apr;140(3-4):198-203.

10. Bhoi SB, Tumram NK, Schinde DK, Chandekar KS. Delayed death after attempted suicide by hanging. J Punjab Acad Forensic Med toxicol 2013;13(2).

11. Badkur D.S, Arorae.A, Jain C.S. Delayed death in a case of attempted strangulation, mechanism of cerebral thrombosis and infarction.- A case report. Journal of Indian Academy of Forensic Medicine; 2005;27(4):263-65.

12. Naik. S.K, Murali.A. Delayed death after homicidal strangulation: A case report. Indian Internet journal of Forensic medicine and Toxicology; 2006;4(2).

13. 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 Oct;43(4):599-604.

14. Camps F.E, Robinson A.E. Gradwohl's Legal Medicine.3rd ed . Bristol: John Right and Sons LTD;1976.

15. Reddy K.S.N. The Essentials of Forensic Medicine and Toxicology.33st ed.NewDelhi.Jaypee Publishers ; 2014.P 338-58

16. Kumar V, Abbas AK, Aster JC . Robbins Basic pathology.9th.New Delhi: Elsevier; 2013.

17. Janssen W. Forensic Histopathology. Germany: Springer Verlag; 1984.