

Contents lists available at [ScienceDirect](http://www.sciencedirect.com)

Egyptian Journal of Forensic Sciences

journal homepage: <http://www.journals.elsevier.com/egyptian-journal-of-forensic-sciences>

ORIGINAL ARTICLE

Ligature material in hanging deaths: The neglected area in forensic examination



Vipul Namdeorao Ambade ^{*}, Nilesh Tumram, Satin Meshram, Jaydeo Borkar

Department of Forensic Medicine, Government Medical College, Nagpur, 440003 Maharashtra State, India

Received 29 March 2014; revised 26 June 2014; accepted 8 July 2014

Available online 7 August 2014

KEYWORDS

Asphyxial deaths;
Hanging;
Ligature material;
Knots;
Direction of hanging mark;
Ligature points

Abstract The hanging mark is the most relevant feature of hanging and its characteristics are well known in the literature. Most of the time, the ligature material is not available during autopsy examination in hanging. Hence, the features of the ligature material are not submitted to systematic analysis. However, the type and position of the knot plays an important role in the mechanism of death and autopsy findings in hanging. Out of the total hanging deaths, complete hanging was seen in 67.7% of the cases, but a typical hanging was noted in only 10.2% of the cases. The commonest type of ligature material used for ligation around the neck was nylon rope followed by odhni and jute rope. The fixed knot was noted in 64.6% of the cases and a running (slip) in 21.3% of the cases. The commonest position of the knot was at nape of the neck, followed by the left side of the neck at mastoid process. The number of turns/loops of a ligature around the neck was one turn in 72.4% and two in 25.2% the hanging deaths. Most victims committed suicide by hanging in their homes, and the commonest ligature points were trees, flowed by beams and ceiling hook/fans.

© 2014 The International Association of Law and Forensic Sciences (IALFS). Production and hosting by Elsevier B.V. All rights reserved.

1. Introduction

Hanging is one of the 10-leading causes of death in the world, accounting for more than a million deaths annually.¹ In India, hanging is one of the common methods of committing suicide along with poisoning, burning and drowning.² Over the past 30 years the incidence of suicide by hanging has increased, especially among young adults.³ Most of the times, the ligature

mark may be the only evidence available in cases of hanging⁴ and its characteristics are well noted in the literature. But the features of the ligature material are not reported for systematic analysis. The type and position of knot play an important role in the causation of death in hanging.⁵ It is represented by an inverted 'V' shaped mark.^{6,7} Against this background, the present study attempted to focus only on the characteristic features of the ligature material and not the ligature mark, so the correlation of features of ligature mark with the different types of ligature material is not included.

2. Material and methods

The study was conducted during the period of 5 years from January 2001 to December 2005. All the autopsies had been

^{*} Corresponding author. Address: 3, Narkesri Apartment, Laxmi Nagar, Nagpur 440022, Maharashtra State, India. Tel.: +91 712 2743588; fax: +91 712 2740832.

E-mail address: vipulambade@rediffmail.com (V.N. Ambade).

Peer review under responsibility of The International Association of Law and Forensic Sciences (IALFS).

<http://dx.doi.org/10.1016/j.ejfs.2014.07.002>

2090-536X © 2014 The International Association of Law and Forensic Sciences (IALFS). Production and hosting by Elsevier B.V. All rights reserved.

performed in the mortuary of Forensic Medicine Department, Government Medical College at Yeotmal, a rural district of Maharashtra, India. The district has a population of 2,458,271 spread over an area of 13,582 km.² The centre is an Apex Medical Centre, where about 70% of the total medicolegal autopsies done across the district are performed here. In India, the police department is legally bound to arrange autopsies in all medicolegal deaths. The Coroner system of examination was abolished in 1999. Previously, it was prevalent only in Mumbai and Kolkata, whereas in the rest of India, only the police or magistrate inquest is available to conduct medicolegal autopsies.⁷ The medicolegal deaths are deaths occurring under unnatural (including suicidal, homicidal and accidental), suspicious or unknown circumstances. The accompanying police papers provide much of the information regarding age, sex, residence, marital status, date of death, reasons and manner of death, and all other relevant information about the case. The autopsy is followed by a mandatory police inquiry and Magistrate's verdict report, especially in regard to the manner of death. Thus, during the study period, 127 cases of hanging were reported in this medical centre which were analysed in reference to ligature material, type and position of the knot, and ligature points. In these hanging deaths, 84.3% of the victims were male and 15.7% were female. The ages ranged from ten to 80 years in males and 13 to 60 years in females.

3. Results

3.1. Types of hanging

As shown in Table 1, complete hanging was seen in 67.7% of the cases and partial (incomplete) hanging in 32.3% of the cases on the basis of body suspension. However, depending on the position of the knot, typical hanging was noted in only 10.2% of the hanging cases and an atypical knot in 89.8% of the cases.

3.2. Ligature material used in hanging

As per Table 2, nylon rope was the commonest type of ligature material used for hanging in 63% of the cases, followed by odhni (10.2%), jute rope (6.3%), and dupatta and sari (5.5% each). Other types of ligature material used for hanging were cotton rope, electric wire/cable, water pipe, shirt, lungi, bed sheet and machine belt. Nylon rope as a ligature material for hanging was preferred by both sexes, but odhni and sari were more preferred more by female victims.

Table 1 Distribution of types of hanging.

Type of hanging	M	%	F	%	T	%
<i>a. Depending on suspension of body</i>						
Complete hanging	73	68.2	13	65.0	86	67.7
Partial hanging	34	31.8	7	35.0	41	32.3
Total	107	100.0	20	100.0	127	100.0
<i>b. Depending on position of knot</i>						
Typical hanging	11	10.3	2	10.0	13	10.2
Atypical hanging	96	89.7	18	90.0	114	89.8
Total	107	100.0	20	100.0	127	100.0

Table 2 Distribution of ligature materials used for hanging.

Ligature material	M	%	F	%	T	%
Nylon rope	72	67.3	8	40.0	80	63.0
Jute rope	8	7.5	0	0.0	8	6.3
Electric wire	2	1.9	0	0.0	2	1.6
Dupatta	7	6.5	0	0.0	7	5.5
Sari	5	4.7	2	10.0	7	5.5
Odhni/chunni	4	3.7	9	45.0	13	10.2
Shirt/lungi/bedsheet	3	2.8	0	0.0	3	2.4
Cotton rope	3	2.8	1	5.0	4	3.1
Plastic water pipe	2	1.9	0	0.0	2	1.6
Machine belt-cotton	1	0.9	0	0.0	1	0.8
Grand total	107	100.0	20	100.0	127	100.0

Dupatta = a scarf worn around head by Indian males, odhni/chunni = a long scarf worn around the neck by Indian females, lungi = a rectangular piece of cloth encircling around waist and lower limbs by one long margin worn by males.

Table 3 Distribution of features of ligature material for hanging.

Ligature material	M	%	F	%	T	%
<i>1. Nature/consistency</i>						
Hard	82	76.6	8	40.0	90	70.9
Firm	6	5.6	1	5.0	7	5.5
Soft	19	17.8	11	55.0	30	23.6
<i>2. Texture</i>						
Cotton	3	2.8	1	5.0	4	3.1
Jute	8	7.5	0	0.0	8	6.3
Nylon	72	67.3	8	40.0	80	63.0
Plastic	2	1.9	0	0.0	2	1.6
Metal wire-electric	2	1.9	0	0.0	2	1.6
Cloth	20	18.7	11	55.0	31	24.4
<i>3. Width</i>						
Narrow (< 1 cm)	85	79.4	9	45.0	94	74.0
Medium (1–2 cm)	7	6.5	4	20.0	11	8.7
Broad (> 2 cm)	15	14.0	7	35.0	22	17.3

3.3. Features of ligature material

As per Table 3, the nature/consistency of the ligature material most commonly used for hanging was of hard material (like nylon rope, jute rope, electric wire) seen in 70.9% of the cases. This is followed by soft material like clothes in 23.6% and firm material (like machine belt, pipe, and cotton rope) in 5.5% of the cases. Male victims preferred hard material but female victims preferred soft material like clothes for ligation. The commonest texture of ligature material used for hanging was of nylon in 63% of the hanging cases, followed by cloth material (24.4%) and jute (6.3%).

In this study the width of the ligature material, can be categorised into three groups; narrow when the width is < 1 cm, medium when the width is between 1–2 cm, and broad when the width is > 2 cm. The most common width used in hanging in this study was the narrow width ligature materials in 74% of the cases; whereas the broad width ligature was used in 17.3% and medium width in 9.7% of the cases.

Table 4 Distribution of different types of knots in hanging.

Type of knots	M	%	F	%	T	%
Fixed	68	63.6	14	70.0	82	64.6
Running (slip)	24	22.4	3	15.0	27	21.3
Not known	15	14.0	3	15.0	18	14.2
Total	107	100.0	20	100.0	127	100.0

3.4. Type of knot

The fixed type of knot was observed in 64.6% of the hanging deaths, while the running (slip) knot was seen in 21.3% of the cases. In 14.2% of hanging deaths, the type of knot was not known due to the removal of the ligature by the relatives or the police (Table 4).

3.5. Position of knot

The direction of the ligature mark was known from the position of the knot. As per Table 5, the knot was commonly placed over the back of the neck in 37% of the cases, the knot was at the occipital protuberance in 10.2% of the cases (typical hanging). The knot was situated on the left side of the neck (left mastoid) in 33.9% of the cases and the right side of the neck (right mastoid) in 24.4% of the cases. The knot on the front of the neck or chin was found in only 4.8% of the cases.

3.6. Number of loops/turns of ligature around the neck

As per Table 6, the number of loops or turns of ligature material around the neck was one loop in 72.4% and two loops in 25.2% of the hangings. But multiple loops were seen around the neck in only 2.4% of the cases.

Table 5 Distribution of different positions of knots in hanging.

Position of knots	M	%	F	%	T	%
Occipital	11	10.3	2	10.0	13	10.2
Either side of occiput	29	27.1	5	25.0	34	26.8
Left mastoid	36	33.6	7	35.0	43	33.9
Right mastoid	26	24.3	5	25.0	31	24.4
Left mandibular	1	0.9	1	5.0	2	1.6
Right mandibular	1	0.9	0	0.0	1	0.8
Chin	3	2.8	0	0.0	3	2.4
Total	107	100.0	20	100.0	127	100.0

Table 6 Distribution of number of loops/ turns of ligature around the neck.

Number of turns	M	%	F	%	T	%
One	75	70.1	17	85.0	92	72.4
Two	29	27.1	3	15.0	32	25.2
Multiple	3	2.8	0	0.0	3	2.4
Total	107	100.0	20	100.0	127	100.0

Table 7 Distribution of ligature points of hanging.

Position of knots	M	%	F	%	T	%
Ceiling fans	8	7.5	5	25.0	13	10.2
Ceiling hooks	23	21.5	3	15.0	26	20.5
Beams	33	30.8	6	30.0	39	30.7
Tree	36	33.6	6	30.0	42	33.1
Ventilator grills	6	5.6	0	0.0	6	4.7
Door bars	1	0.9	0	0.0	1	0.8
Total	107	100.0	20	100.0	127	100.0

Beam = in rural areas it is made of iron or wooden blogs just below roof, Ventilator grills = it is made for aeration either in the toilet/ bathroom or situated above window or door of any room.

Table 8 Distribution of bodies as per place of hanging.

Place of hanging	M	%	F	%	T	%
Home	67	62.6	14	70.0	81	63.8
Hostel	1	0.9	1	5.0	2	1.6
Farm	16	15.0	4	20.0	20	15.7
Barren land	12	11.2	0	0.0	12	9.4
Forest	7	6.5	1	5.0	8	6.3
Hospital	2	1.9	0	0.0	2	1.6
Prison/police station	2	1.9	0	0.0	2	1.6
Total	107	84.3	20	15.7	127	100.0

3.7. Ligature points

The ligature point is a fixed structure to which the other end of the ligature material is tied to in hanging. As shown in Table 7, the commonest ligature point was a tree (33.1%) followed by a beam (30.7%) a ceiling hook (20.5%) and a ceiling fan (10.2%). The other ligature points were a ventilator grill (of toilet/bathroom or other room) and the iron bar of a door.

3.8. Place of hanging

As per Table 8, most victims preferred the home (63.8%) for committing suicidal hanging, followed by a farm (15.7%), a barren land (9.4%) and a forest (6.3%). Only two victims each were recovered from a hostel and a hospital. None of the female victims of hanging were found in a barren land and only one female victim was recovered from the forest.

4. Discussion

In most situations, the ligature material is not available during the forensic examination of hanging. Either, it was brought separately along with the body or sent later on for the examination if required by the investigating officer, or the relatives attempted to rescue the victim by removing the ligature from around the neck. However, despite the fact that the ligature is not available, the police prepare the inquest and include the statements of eye witnesses regarding the reasons and manner of death. In addition to this, at the time of autopsy, the

police also provide an additional 'spot inquest' that contains the detailed description of the scene of crime/ death in relation to the dead body with pictorial representation and/or the photographs of the spot. This information may help in framing the manner of death in such circumstances or even when the body is highly decomposed. Hence, the ligature material is usually not examined; and its features are not submitted for systematic analysis. But, the type and position of the knot plays an important role in the mechanism of death and autopsy findings in hanging.⁵ It is represented by an inverted 'V' shaped mark over the neck.^{6,7} The knot is the point of the ligature around the neck where the maximum force of traction occurs and the part of the ligature diagonally opposite to the knot bears the maximum body weight thus exerting maximum pressure on the underlying neck structures.^{5,7} Moreover, the position of the knot determines whether the effects of pressure/traction are unilateral or bilateral.⁵ If the direction of flow of the saliva or other body fluids is not consistent with the position of the knot then it suggests a suspicious death/foul play. Hence, the features of the ligature material are important from the point of view of forensic examination.

In hanging deaths, complete hanging predominates over the partial (incomplete) hanging^{8,9} and this finding is well correlated with the present study. Saisudheer and Nagaraja¹⁰ and Penaranda et al.¹¹ also reported complete hanging in 64% and 62.4% deaths respectively and feet touching the ground in most of the cases of partial hanging. Ahmad and Hossain¹² found 97.2% complete hanging, whereas Sharma et al.¹³ found 46% complete and 54% partial hangings. But depending on the position of the knot, typical hanging was noted in only 10.2% of the cases in the present study. In typical hanging, the knot is placed over the occipital region, whereas in judicial hanging the knot is placed over the chin.^{6,7}

The commonest type of ligature material used for hanging was a nylon rope followed by an odhni and jute rope. However, female victims preferred an odhni and a nylon rope for ligation over the neck. Sharma et al.¹³ noted chunni as the commonest ligature material used followed by nylon rope and jute rope. Ahmad and Hussain¹² and Patel et al.¹⁴ reported dupatta/chunni as the commonest ligature material used for hanging. But Tumram et al.⁴ reported the nylon rope as the commonest type of ligature material used for hanging followed by the odhni, dupatta and sari in the Nagpur region of central India.

In relation to the features of the ligature material, the hard ligature material was commonly used for hanging followed by soft material and firm material. Saisudheer and Nagaraja¹⁰ and Patel et al.¹⁴ reported a soft material like cloth followed by a firm material like rope as the preferred choice of ligature material for hanging. The commonest texture of the ligature material was of nylon in 63% of the cases, followed by cloth material and jute texture in the present study. Also the narrow width ligature material was commonly used for ligation in the present series. This is probably due to the easy availability and accessibility of a nylon rope used for domestic work for the purpose of ligation.

With regard to the type of knot, the fixed knot predominated in hanging deaths.¹¹ But, Saisudheer and Nagaraja¹⁰ reported the predominance of a slip (running noose) type of knot followed by a reef or granny knot in hanging deaths. Badkur et al.⁵ noted 70.5% for the sliding type of knot. However, Patel et al.¹⁴ reported 46.3% for the fixed and

53.7% for the running type of knot. Sharma et al.¹³ noted 58.8% for the fixed and 42.3% for the slip type of knot in hanging deaths. In 14.2% of the cases, the type of knot was not known due to the early loosening and removal of the knot by the relatives of the deceased in order to take the victim for emergency treatment. Penaranda et al.¹¹ also noted that the type of knot was not known in 13.1% of hanging deaths. However, Badkur et al.⁵ reported that the type of knot could not be ascertained in only 4% of hanging cases.

In the present study, the knot was commonly placed over the back of the neck (37%) but typical hanging was seen in 10.2% of the cases. The knot was on the left side of the neck in 33.9% and on the right side in 24.4% of the cases. The knot on the front of the neck was very rare and noted in only 4.8% of the cases. These findings are in consistence with those reported by Penaranda et al.¹¹ Saisudheer and Nagaraja¹⁰ and Sharma et al.¹³ found that the knot was commonly placed on the left side of the neck, followed by the right side and the back of the neck. But, Ahmad and Hossain¹² noted the knot more commonly on the right side followed by the left side.

The turns/loops of the ligature material around the neck are one loop, which is evident by a single hanging mark over the neck. The hanging mark usually being single and lying above the thyroid cartilage, has been reported in many literature.^{15,16} Penaranda et al.,¹¹ Saisudheer and Nagaraja,¹⁰ Patel et al.¹⁴ and Sharma et al.¹⁴ also reported the same findings. In the present study, the number of loops/turns was one loop in 72.4% of the cases. However, when a thin material like a jute rope or electric wire was used, they were applied around the neck with more than one loop.

As far as the place of hanging and the ligature points are concerned, the home (63.8%) was the commonest place for hanging followed by an agricultural farm (15.7%) and a barren land (9.4%) and a forest (6.3%). Moreover, females preferred the home and a farm more as compared to males for committing suicidal hangings, which was clear from the fact that only one female body was noted either in a forest or a barren land. Vijayakumari¹⁷ and Ahmad and Hossain¹² reported that more than 95% of victims preferred the home for committing suicide by hanging. This is probably due to its secluded environment and easy accessibility of different ligature materials available at the home for ligation. In spite of this, trees were the commonest ligature points in hanging deaths followed by beams, ceiling hooks/fans. Vijayakumari¹⁷ also reported ceiling fans, beams and grills as the common ligature points in hanging deaths. This is because the victims who has committed suicidal hanging at the home had an option of ceiling hooks/fans, beams, grill, etc. as ligature points. But, if the victims committed suicide by hanging in an agricultural farm, barren land and forest, then trees are the only available ligature points.

5. Conclusions

Thus this study has systematically analysed the features of ligature material in hanging. A careful examination of the ligature material is very important while giving an opinion in hanging. The type and position of the knots are necessary to correlate the autopsy findings and mechanism of death in hanging. Any gross inconsistencies in this regard may create doubt of foul play or suspicious death.

Funding

None.

Conflict of interest

None declared.

Ethical approval

Necessary ethical approval was obtained from Government Medical College at Yeotmal, a rural district of Maharashtra, India.

References

1. Mohanty S, Sahu G, Mohanty MK. Suicide in India – a four year retrospective study. *J. Forensic Leg. Med.* 2007;**14**(2):185–9.
2. Ambade VN, Keoliya AN, Wankhede AG. Availability of means of suicides. *Int J Med Toxicol Leg Med* 2012;**14**:83–9.
3. Gunnell D, Bennewith O, Hawton K, Simkin S, Kapur N. The epidemiology and prevention of suicide by hanging: a systematic review. *Int J Epidemiol* 2006;**34**(2):433–42.
4. Tumram NK, Ambade VN, Bardale RJ, Dixit PG. Injuries over neck in hanging deaths and its relation with ligature material: is it vital? *J Forensic Leg Med* 2014;**22**:82–3.
5. Badkur DS, Yadav J, Arora A, Bajpayee R, Dubey BP. Nomenclature for knot position in hanging – a study of 200 cases. *J Indian Acad Forensic Med* 2012;**34**(1):34–6.
6. Reddy KSN. *The essential of forensic medicine and toxicology*. 31st ed. Hyderabad: Om Sai Graphics; 2012, p. 314–22.
7. Dikshit PC. *Textbook of forensic medicine and toxicology*. 2nd ed. New Delhi: Peepee Publishers and Distributors (P) Ltd; 2014. p. 294–304.
8. Elfawal M, Awad O. Deaths from hanging in the Eastern Province of Saudi Arabia. *Med Sci Law* 1994;**34**:307–12.
9. Lester D. Suicide and homicide in Costa Rica. *Med Sci Law* 1995;**35**:316–9.
10. Saisudheer T, Nagaraja TV. A study of ligature mark in cases of hanging deaths. *Int J Pharm Biomed* 2012;**3**(3):80–4.
11. Suarez-Penaranda JM, Alvarez T, Miguens X, Rodriguez-Calva B, Lopez de Abajo B, Cortesao M, et al. Characterization of lesions in hanging deaths. *J Forensic Sci* 2008;**53**(3):720–3.
12. Ahmad M, Hossain MZ. Hanging as a method of suicide: Retrospective analysis of postmortem cases. *J AFMC, Bangladesh* 2010;**6**(2):37–9.
13. Sharma BR, Harish D, Singh VP, Singh P. Ligature mark on neck: how informative? *J Indian Acad Forensic Med* 2005;**27**(1):10–3.
14. Patel AP, Bansal A, Sheikh IV, Sheikh KA. Study of hanging cases in Ahmedabad region. *J Indian Acad Forensic Med* 2012;**34**(4):342–5.
15. Spitz WU, editor. *Spitz and Fisher's medicolegal investigation of death*. 3rd ed. Springfield, IL: Charles C. Thomas; 1993. p. 444–97.
16. Di Maio DJ, Di Maio D. *Forensic pathology*. New York: CRC Press LLC; 2001, p. 229–77.
17. Vijayakumari N. Suicidal hanging: a prospective study. *J Indian Acad Forensic Med* 2011;**33**(4):355–7.