



Original Article

Forensic and Histopathological Evaluation of Ligature Marks in cases of delayed death due to Hanging: A Retrospective study

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ABSTRACT

Background: Hanging is the most common method of suicidal deaths in India. Almost all cases of hanging are suicidal unless otherwise proved. It takes some time to develop tissue reaction after the body was suspended by a ligature material and its should be confirmed by histopathological examination. Based on the tissue reaction under the ligature mark we can estimate the duration of survival after an attempted hanging. However, the tissue reaction depends on the type of ligature material used and the degree of suspension. The objective of this study is to determine the age, sex, duration of survival, type of suspension and type of ligature material and to correlation between duration of survival and clinical findings among delayed death due to hanging and to analyze the temporal correlation between duration of survival after attempted hanging and histopathological changes.

Material and methods: Retrospective observational study carried out in the Department of Forensic medicine and Toxicology, Karnataka Medical College and Research Institute, Hubballi. The cases were selected based on the history written in form 146 (ii) and the duration of survival after alleged history of hanging and the deceased was treated in the hospital for minutes to days.

Results: 12 cases of delayed hanging death were studied. Out of which, 8 (66.7%) were female and the mean age is 31+11.732years. Household fabrics, particularly dupatta (41.7%) and saree (33.3%), were the most commonly used ligature materials. The duration of hospital stay varied; most patients stayed between 3 to 7 days (41.7%). The HPE of the ligature mark Normal epidermis was noted in 16.7% of cases, whereas ulceration and focal ulceration were observed in 16.7% each. Dermal changes, including congestion, edema, focal separation, and haemorrhage, were observed in a minority of cases, with congestion being most frequent (33.3%). Inflammatory cell infiltrates were common, with predominant neutrophils and lymphocytes observed in 41.7% of cases. The cause of death was most commonly attributed to infection of the lungs (41.7%), followed by hypoxic encephalopathy (25%) and asphyxia (16.7%).

Conclusion: Histopathological examination of pressure abrasion due to hanging can provide valuable insights into the nature, type of ligature material used and timing of the injury sustained. Determining the survival period and prognosis for patients with hanging injuries can be challenging.

Keywords: Hanging, survival duration, delayed death, ligature mark, histopathological changes.

INTRODUCTION

Hanging is a form of asphyxia death, which is caused by suspension of the body by a ligature encircling the neck, the constricting force being the weight of the body. It is most common method of suicide in India¹. It is the most common cause of death by suicide followed by poisoning.² The term “near hanging” refers to individuals who survive a hanging attempt long enough to receive hospital care. However, which is highly fatal as majority die before reaching hospital. Rapid and effective intervention can be crucial in saving their lives. However, some victims may later die due to complications that arise after a period of survival—this outcome is known as delayed hanging death.³ Delayed death due to hanging is very rare and there are multiple causes for it and most commonly is due to its complications of pressure over the neck.

The healing process of other type of abrasion could be different as there is only superficial layer of the skin tissue that is epidermis will be injured but though the ligature mark is also a abrasion but it is a pressure abrasion which not only involve epidermis but also involve the dermal and deeper tissues. In general the healing process of abrasion is a well-known fact but the healing process of pressure abrasion due to ligature mark are not studied extensively as a result the literatures are lacking. Hence, this study was under taken to know the healing process of pressure abrasion (compression of neck) over the neck by ligature material through histopathological examination of ligature mark.

OBJECTIVES OF THE STUDY

1. To study the age, sex, duration of survival, type of suspension and type of ligature material.
2. To study the correlation between duration of survival and clinical findings.
3. To study the temporal correlation between duration of survival after attempted hanging and histopathological changes.

MATERIALS AND METHODS

This retrospective observational study was conducted in the Department of Forensic medicine and Toxicology, Karnataka Medical College and Research Institute, Hubballi by retrieving the last 2 year data that is from January 2023 to December 2024. Of 2933 cases, 299 cases of hanging were brought for medicolegal postmortem examination out of which 25 cases were delayed death due to hanging out of which 12 cases with histopathological findings of ligature mark were included in this study. The details of the cases were collected from inquest and postmortem examination report. Clinical findings and the survival duration of these case were reviewed from hospital case sheet. The photographs were taken during case review and while conducting postmortem examination.

The data were statistically analysed using SPSS statistical package for social sciences version 26 and Microsoft excel 2021. The data were segregated with respect to age, sex, survival duration, ligature material, histopathological parameters, cause of death, history, condition of the patient when brought to hospital and GCS score were noted.



Figure 1 and 2: Photographs of the treated hanging case showing healed ligature mark, with scab formation and areas of hypopigmentation.

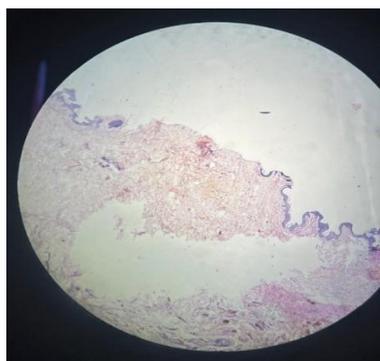


Fig 3: Section from skin under ligature mark shows thinned out epidermis and ulceration. Dermis shows micro haemorrhages.



Fig 4: section from skin under ligature mark shows scab in stratum corneum. Dermis shows mild inflammatory infiltrate of lymphocytes.

RESULTS

Table 1: Showing descriptive statistics.

Age	Age	Mean±SD	
		31±11.732	
		Frequency (out of 12)	Percent
Age	10 to 20	1	8.3
	21 to 30	6	50.0
	31 to 40	3	25.0
	41 to 50	1	8.3
	> 50	1	8.3
Sex	Female	8	66.7
	Male	4	33.3
Duration days in	6 to 12 hr	1	8.3
	12 to 24 hr	1	8.3
	1 to 2 Days	2	16.7
	3 to 7 Days	5	41.7
	7 to 12 Days	1	8.3
	>12 D Days	2	16.7
Ligature material	Dupatta	5	41.7
	Metallic wire	1	8.3
	Plastic wire	1	8.3
	Rope	1	8.3
	Saree	4	33.3
Epidermis	Normal	2	16.7
	Mononuclear cell infiltrate	1	8.3
	Thinning	1	8.3
	dermal and epidermal separation	1	8.3
	Subepidermal edema	1	8.3
	Congestion	1	8.3
	Ulceration	2	16.7
	Scab	1	8.3
	Focal ulceration	2	16.7
	Erosion	1	8.3
Dermis	Microvascular congestion	1	8.3
	Focal separation	2	16.7
	Edema	3	25.0
	Congestion	7	58.3
	haemorrhagic	2	16.7
	Moderate lymphocytic infiltrate	1	8.3
	Pigmented macrophages	1	8.3
	Neutrophils	5	41.7
	Lymphocytes other	5	41.7
	Mixed inflammatory cells	2	16.7
	Pigmented macrophages	1	8.3
Cause of death	Asphyxia	2	16.7
	Septicaemia	1	8.3
	Hypoxic encephalopathy	3	25.0
	Infection of lungs	5	41.7
	Injuries sustained	1	8.3
History	Complete Hanging	7	58.3
	Others	2	16.7
	Partial Hanging	3	25.0
Consciousness	Conscious	4	33.3
	Drowsy	1	8.3
	Unconscious	6	58.3
Oriented	Disoriented	9	75.0
	Irritable	1	8.3

	Oriented	2	16.7
GCS	E1V2M4	1	8.3
	E1VTM1	5	41.7
	E2V1M4	3	25.0
	E2V2M4	1	8.3
	E2VTM2	1	8.3
	E2VTM4	1	8.3
Tracheostomy	No	6	50.0
	Yes	6	50.0
Diagnosis	Complete hanging HIE Sever brainstem dysfunction neurogenic ARDS Acute myocarditis with heart failure reduced ejection fraction 935%)	1	8.3
	Complete hanging with grade 3 HIE	2	16.7
	Complete hanging with grade 4 HIE	3	25.0
	Fracture of 6th and 7th cervical vertebrae with retrolisthesis of C4,5,6 and 7 secondary to hanging	1	8.3
	Partial hanging with grade 3 HIE, Alcohol use disorder with MODS	1	8.3
	Partial hanging with HIE, Aspiration pneumonia	1	8.3
	Partial hanging with HIE, MODS	1	8.3
	Sever asphyxia with HIE with MODS secondary to hanging	1	8.3
	Spinal shock	1	8.3

The study included 12 patients with a mean age of 31 ± 11.7 years. The age distribution of the study participants revealed that the majority were in the 21–30 years age group, accounting for 50% (n=6) of the total sample. This was followed by the 31–40 years group with 25% (n=3) of participants. A smaller proportion belonged to the 10–20 years age group (8.3%, n=1), 41–50 years group (8.3%, n=1), and those aged above 50 years (8.3%, n=1). This shows that the study population was predominantly composed of young adults, with very few participants from adolescent and older age categories. The skew towards younger age groups may reflect the epidemiological trend of the condition under study or sampling characteristics.

Among them, females accounted for the majority (66.7%, n=8), while males comprised 33.3% (n=4). The duration of hospital stay varied; most patients stayed between 3 to 7 days (41.7%), followed by 1 to 2 days (16.7%) and more than 12 days (16.7%). A smaller proportion remained for 6–12 hours, 12–24 hours, or 7–12 days (each 8.3%). Regarding ligature materials used, dupatta was most common (41.7%), followed by saree (33.3%), while metallic wire, plastic wire, and rope were less frequently employed (8.3% each).

Histopathological examination of the epidermis revealed a wide spectrum of changes. Normal epidermis was noted in 16.7% of cases, whereas ulceration and focal ulceration were observed in 16.7% each. Subepidermal edema, congestion, erosion, mononuclear infiltrate, thinning, scab formation, and dermal–epidermal separation were individually seen in 8.3% of cases. In the dermis, congestion was the most frequent finding (33.3%), followed by edema (25%) and mild congestion (25%). Inflammatory cell infiltrates were common, with neutrophils and lymphocytes both observed in 41.7% of cases. Other features included focal separation (16.7%), mixed inflammatory cells (16.7%), haemorrhagic changes (16.7%), pigmented macrophages (8.3%), and moderate lymphocytic infiltration (8.3%).

The cause of death was most commonly attributed to infection of the lungs (41.7%), followed by hypoxic encephalopathy (25%) and asphyxia (16.7%). Less frequent causes included septicaemia (8.3%) and injuries sustained (8.3%). Based on event history, complete hanging accounted for 58.3% of cases, partial hanging for 25%, and other forms for 16.7%. At the time of presentation, 58.3% were unconscious, 33.3% conscious, and 8.3% drowsy. Orientation status was available in some cases, with 16.7% oriented and 8.3% disoriented, while data were not available for the majority (66.7%).

Neurological assessment with the Glasgow Coma Scale (GCS) revealed that the most frequent score was E1VTM1 (41.7%), followed by E2V1M4 (25%). Other scores such as E1V2M4, E2V2M4, E2VTM2, and E2VTM4 were seen in 8.3% of patients each. Tracheostomy was required in 50% of the cases. The final diagnoses reflected the severity of the insult. Complete hanging with grade 4 hypoxic ischemic encephalopathy (HIE) was diagnosed in 25% of patients, while grade 3 HIE was seen in 16.7%. Other diagnoses included severe brainstem dysfunction with neurogenic ARDS and acute myocarditis (8.3%), cervical vertebral fractures with retrolisthesis (8.3%), partial hanging with grade 3 HIE and multi-organ dysfunction syndrome (MODS) (8.3%), partial hanging with aspiration pneumonia (8.3%), partial hanging with HIE and MODS (8.3%), severe asphyxia with HIE and MODS (8.3%), and spinal shock (8.3%).

Table 2: Showing Chi-square test to association between Histopathological finding with different ligature material.

Chi-Square Test						
Histopathological Finding	Ligature material					p-value
	Dupatta	Metallic wire	Plastic wire	Rope	Saree	
Mononuclear cell infiltrate (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.758
Thinning (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.758
Dermal & epidermal separation (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.758
Subepidermal edema (Epidermis)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0.665
Congestion (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.758
Ulceration (Epidermis)	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0.860
Scab (Epidermis)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0.665
Erosion (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.758
Focal ulceration (Epidermis)	0 (0.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0.177
Microvascular congestion (Dermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.758
Focal separation (Dermis)	1 (50.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)	0.214
Edema (Dermis)	2 (66.7%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	0.149
Congestion (Dermis)	2 (40.0%)	1 (100.0%)	0 (0.0%)	1 (100.0%)	3 (75.0%)	0.280
Haemorrhagic (Dermis)	0 (0.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0.177
Moderate lymphocytic infiltrate (Dermis)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0.665
Pigmented macrophages (Dermis)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.142
Neutrophils (Infiltration)	3 (60.0%)	0 (0.0%)	0 (0.0%)	1 (20.0%)	1 (20.0%)	0.280
Lymphocytes others (Infiltration)	3 (60.0%)	0 (0.0%)	1 (20.0%)	0 (0.0%)	1 (20.0%)	0.280
Mixed inflammatory cells (Infiltration)	2 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.395
Pigmented macrophages (Infiltration)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0.665

Association between Ligature Material and Specific Epidermal Findings: No statistically significant associations were observed between ligature material and individual epidermal features, including mononuclear cell infiltrate (p=0.758), thinning (p=0.758), dermal–epidermal separation (p=0.758), subepidermal edema (p=0.665), congestion (p=0.758), ulceration (p=0.860), scab formation (p=0.665), erosion (p=0.758), or focal ulceration (p=0.177). Although some features like focal ulceration were more frequent with saree and metallic wire, and subepidermal edema or scab formation appeared exclusively with saree, the differences were not statistically significant, likely due to small case numbers.

Association between Ligature Material and Dermal Histological Changes: The Chi-square test did not reveal significant associations between ligature material and most dermal changes, including microvascular congestion (p=0.758), focal separation (p=0.214), edema (p=0.149), , congestion (p=0.280), haemorrhagic changes (p=0.177), moderate lymphocytic infiltrate (p=0.665), or pigmented macrophages (p=0.142). Notably, mild congestion appeared more frequently in saree-related cases, and edema was more common in dupatta-related incidents. However, these patterns lacked statistical significance.

Association between Ligature Material and Inflammatory Cell Infiltration: There was no significant relationship between ligature type and inflammatory infiltrates in dermis or subcutaneous tissue. Neutrophilic infiltration ($p=0.280$) was more common in dupatta cases (60%), followed by rope and saree (20% each). Lymphocytic infiltration ($p=0.280$) also followed a similar pattern. Mixed inflammatory cell infiltration occurred exclusively with dupatta ($p=0.395$), while pigmented macrophages in infiltrates were seen only with saree ($p=0.665$). These findings indicate possible trends but not statistically robust associations.

Table 3: Showing Chi-square test to association type of hanging with different ligature material.

Chi square test					
		Complete Hanging	Partial Hanging	Others	p-value
Ligature Material	Dupatta	4 (57.1%)	0 (0.0%)	1 (50.0%)	0.131
	Metallic wire	0 (0.0%)	1 (33.3%)	0 (0.0%)	
	Plastic wire	0 (0.0%)	0 (0.0%)	1 (50.0%)	
	Rope	1 (14.3%)	0 (0.0%)	0 (0.0%)	
	Saree	2 (28.6%)	2 (66.7%)	0 (0.0%)	

The association between ligature material and history of hanging was assessed using the Chi-square test. Dupatta was most frequent, seen in 57.1% of complete hangings and 50% of "other" cases, but absent in partial hangings. Saree use was common in both complete (28.6%) and partial hangings (66.7%), while rope (14.3%), metallic wire (33.3%), and plastic wire (50% of "others") occurred sporadically. The test showed no significant association ($p = 0.131$), suggesting ligature choice reflects availability and circumstance rather than type of hanging.

Table 4: Showing Chi-square test to association history with Histopathological finding.

Chi square test				
Variable	History			p-value
	Complete Hanging	Partial Hanging	Others	
Mononuclear cell infiltrate (Epidermis)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0.128
Thinning (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.565
Dermal & epidermal separation (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.565
Subepidermal edema (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.565
Congestion (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.565
Ulceration (Epidermis)	1 (50.0%)	1 (50.0%)	0 (0.0%)	0.535
Scab (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.565
Focal ulceration (Epidermis)	0 (0.0%)	2 (100.0%)	0 (0.0%)	0.030*
Erosion (Epidermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.565
Microvascular congestion (Dermis)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0.128
Focal separation (Dermis)	2 (100.0%)	0 (0.0%)	0 (0.0%)	0.296
Edema (Dermis)	3 (100.0%)	0 (0.0%)	0 (0.0%)	0.140
Congestion (Dermis)	4 (57.1.0%)	3(100.0%)	0 (100.0%)	0.034*
Hemorrhagic (Dermis)	1 (50.0%)	1 (50.0%)	0 (0.0%)	0.535
Moderate lymphocytic infiltrate (Dermis)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.565
Pigmented macrophages (Dermis)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0.128
Neutrophils (Infiltration)	4 (80.0%)	0 (0.0%)	1 (20.0%)	0.138
Lymphocytes others (Infiltration)	3 (60.0%)	0 (0.0%)	2 (40.0%)	0.034*
Pigmented macrophages (Infiltration)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0.565
Mixed inflammatory cells (Infiltration)	6 (60.0%)	3 (30.0%)	1 (10.0%)	0.317

The association between the type of hanging (complete, partial, and others) and various histopathological changes was analyzed using the Chi-square test. Most of the epidermal and dermal changes did not show statistically significant associations with the type of hanging, although certain trends were noted.

In the **epidermal findings**, mononuclear cell infiltrate was observed exclusively in the "others" category (100.0%, $p=0.128$). Thinning of the epidermis, dermal and epidermal separation, subepidermal edema, congestion, and erosion were each seen only in cases of complete hanging (100.0% each, $p=0.565$). Ulceration of the epidermis was more widely distributed, with equal frequency in complete and partial hanging (50.0% each, $p=0.535$). The occurrence of scab formation was confined to complete hanging (100.0%, $p=0.565$). Interestingly, focal ulceration was noted only in partial hanging (100.0%), and this finding was statistically significant ($p=0.030$), indicating a possible relationship between this histological change and partial suspension.

With respect to **dermal findings**, microvascular congestion and pigmented macrophages were found exclusively in the "others" category (100.0% each, $p=0.128$). Focal separation and edema were present only in complete hanging (100.0%,

p=0.296 and p=0.140, respectively). congestion was more frequent in partial hanging (100.0%) compared to complete hanging (57.1%), association was statistical significance (p=0.034). General dermal congestion was predominantly associated with complete hanging (75.0%) and less so with partial hanging (25.0%, p=0.387). Haemorrhagic changes were equally distributed between complete and partial hanging (50.0% each, p=0.535). Moderate lymphocytic infiltrates occurred exclusively in complete hanging (100.0%, p=0.565).

Among the **inflammatory infiltrates**, neutrophil predominance was observed mainly in complete hanging (80.0%), with occasional presence in the "others" group (20.0%, p=0.138). Lymphocytic infiltrates were more frequent in complete hanging (60.0%), but notably, 40.0% were seen in the "others" group, and this association was statistically significant (p=0.034). Pigmented macrophages under infiltration were restricted to complete hanging (100.0%, p=0.565). Mixed inflammatory cell infiltration was common across categories, being highest in complete hanging (60.0%), followed by partial hanging (30.0%) and others (10.0%), though without statistical significance (p=0.317).

Table 5: Showing Chi-square test to association duration in days with Histopathological finding.

Chi square test							
Finding	Duration in days						p-value
	6-12 hr	12-24 hr	1-2 Days	3-7 Days	7-12 Days	>12 Days	
Mononuclear cell infiltrate (Epidermis)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0.533
Thinning (Epidermis)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0.865
Dermal & epidermal separation (Epidermis)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0.865
Subepidermal edema (Epidermis)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	0.533
Congestion (Epidermis)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	0.533
Ulceration (Epidermis)	1 (50%)	0 (0%)	0 (0%)	1 (50%)	0 (0%)	0 (0%)	0.325
Scab (Epidermis)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0.865
Focal ulceration (Epidermis)	0 (0%)	0 (0%)	0 (0%)	1 (50%)	1 (50%)	0 (0%)	0.325
Erosion (Epidermis)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0.865
Microvascular congestion (Dermis)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0.533
Focal separation (Dermis)	0 (0%)	1 (50%)	1 (50%)	0 (0%)	0 (0%)	0 (0%)	0.154
Edema (Dermis)	0 (0%)	1 (33.3%)	1 (33.3%)	1 (33.3%)	0 (0%)	0 (0%)	0.334
Congestion (Dermis)	1 (100%)	1 (100%)	1 (50%)	3 (60%)	1 (100%)	0 (0%)	0.236
Hemorrhagic (Dermis)	0 (0%)	0 (0%)	1 (50%)	1 (50%)	0 (0%)	0 (0%)	0.694
Moderate lymphocytic infiltrate (Dermis)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0.865
Pigmented macrophages (Dermis)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0.533
Neutrophils (Infiltration)	0 (0%)	1 (20%)	2 (40%)	1 (20%)	0 (0%)	1 (20%)	0.130
Lymphocytes others (Infiltration)	0 (0%)	0 (0%)	0 (0%)	3 (60%)	0 (0%)	2 (40%)	0.088
Pigmented macrophages (Infiltration)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0.865
Mixed inflammatory cells (Infiltration)	1 (10%)	1 (10%)	2 (20%)	4 (40%)	1 (10%)	1 (10%)	0.694

The relationship between the duration of survival after hanging and histopathological findings was assessed using the Chi-square test. Overall, most epidermal, dermal, and inflammatory changes did not demonstrate statistically significant associations with duration, though a few parameters showed notable trends.

In the epidermal layer, mononuclear cell infiltrates were observed exclusively beyond 12 days (100.0%, p=0.533). Thinning of the epidermis, dermal-epidermal separation, scab formation, and erosion were restricted to the 3-7 day group (100.0% each, p=0.865). Subepidermal edema and epidermal congestion occurred at 1-2 days (100.0% each, p=0.533). Ulceration

was distributed between early (6–12 hr, 50.0%) and intermediate (3–7 days, 50.0%) survival ($p=0.325$). Focal ulceration was more prolonged, being present in both 3–7 days and 7–12 days equally (50.0% each, $p=0.325$).

With regard to dermal alterations, microvascular congestion and pigmented macrophages appeared late, beyond 12 days (100.0% each, $p=0.533$). Focal separation occurred at 12–24 hr (50.0%) and 1–2 days (50.0%, $p=0.154$). Dermal edema was noted across 12–24 hr, 1–2 days, and 3–7 days (33.3% each, $p=0.334$). General dermal congestion was most frequently seen at 6 to 12hr, 12 to 24hrs and 7 to 12 days (100%), 3–7 days (60.0%), followed by 1–2 days (50.0%, $p=0.236$). Hemorrhagic changes were equally divided between 1–2 days and 3–7 days (50.0% each, $p=0.694$). Moderate lymphocytic infiltration was confined to the 3–7 day group (100.0%, $p=0.865$).

For the inflammatory infiltrates, neutrophils were observed at multiple time intervals, being highest at 1–2 days (40.0%), followed by 12–24 hr (20.0%), 3–7 days (20.0%), and beyond 12 days (20.0%), though not statistically significant ($p=0.130$). Lymphocytic infiltrates were more frequent in the intermediate durations, with 60.0% at 3–7 days and 40.0% beyond 12 days, approaching statistical significance ($p=0.088$). Pigmented macrophages were identified only at 3–7 days (100.0%, $p=0.865$). Mixed inflammatory cell infiltrates were distributed across all time points, with the majority at 3–7 days (40.0%), followed by 1–2 days (20.0%), and smaller proportions at 6–12 hr, 12–24 hr, 7–12 days, and >12 days (10.0% each, $p=0.694$).

DISCUSSION

In the present study, we examined the histopathological features of ligature marks in hanging cases, analysing epidermal and dermal changes along with demographic characteristics, ligature materials, type of hanging, and hospital stay duration. Our findings provide insights into the microscopic alterations in skin tissue i.e., epidermal and dermal changes with duration of survival after delayed death due to hanging. The age distribution range between 13 to 57 years, with a mean age of 31 ± 11.7 years. Female constitute the majority of the study population, which is in correlation with study done by Konstantinos Tsirigotis et al., indicating that women are more likely to survive suicide attempts, whereas men are more likely to die by suicide, often using more violent methods. There was incomplete ligature mark which shows scab formation with hypopigmented areas. Household fabrics, particularly dupatta (41.7%) and saree (33.3%), were the most commonly used ligature materials in our study. This aligns with Harish et al., who reported that the 88% used soft ligature material in that shawl (32%), Lungi/Dhoti (28%) followed by saree (24%) and coir rope and nylon rope were less frequently used by the survived group in contrast these material were frequently used in brought dead cases which is in consistent with the study done by Shoba et al., who reported rope as the predominant material (60.8%), followed by saree (21.5%) and dupatta (10.1%), and with Jiwane et al., who observed nylon rope as the most frequent ligature (48.57%). These findings suggest that while rope remains common globally in non-survived population, and domestic fabrics are frequently employed in female victims and those who survived after hanging act, the survival duration also depends on the type, texture, and width of ligature materials may influence epidermal and dermal injury patterns. Histopathological examination revealed abnormal epidermis in 83.3% of cases, though specific features such as ulceration and focal ulceration seen in 16.7%, whereas congestion, scab formation and erosion seen in 8.3%. Most epidermal and dermal changes such as thinning, congestion, edema, and ulceration were observed with dupatta and saree as ligatures. Findings like pigmented macrophages and moderate lymphocytic infiltrates were rare and limited to single ligature type, The limited occurrence of inflammatory infiltration in our study, with mononuclear cells present in only 8.3% of cases, aligns with case report of R. Hausmann et al., mild leukocytic and mononuclear infiltrates in the corium, indicating that inflammatory responses are influenced by the duration of survival, type of hanging and the material used. Dermal changes, including congestion, edema, focal separation, and haemorrhage, were observed in a minority of cases, with congestion being most frequent (33.3%). These findings corroborate reports by Sahu et al., who found keratinocyte compression and dermal congestion in 52–58% of cases, and Shoba et al., who documented dermal congestion in 45.5% and haemorrhage in 21.5%, highlighting the heterogeneity of dermal responses depending on ligature type, site placement, duration of compression and survival period. Inflammatory cell infiltration in our study showed neutrophilic and lymphocytic presence in 41.7% of cases each, while mixed infiltrates were rare. Jiwane et al. observed leukocyte infiltration in only 2.85% of cases, and Sahu et al. reported minimal inflammatory changes with soft and broad ligature materials, indicating that inflammation may not consistently occur in rapid deaths. Clinically, pulmonary infection (41.7%), hypoxic encephalopathy (25%), and asphyxia (16.7%) were the leading causes of death, highlighting secondary complications following hanging, as similarly noted by Jiwane et al., and Swapan Debbarma et al. The severity of neurological impairment at admission, evidenced by unconsciousness in 58.3% of cases and variable Glasgow Coma Scale scores, along with the need for tracheostomy in half the cases, underscores the critical importance of immediate airway management. In our study only mild congestion in the dermis showed a statistically significant association ($p = 0.019$), being distributed across 6–12 hours, 12–24 hours, and 7–12 days, suggesting that vascular response in the dermis may evolve with increasing time after injury and most histopathological changes could not be strongly linked to the exact duration of hanging, though a trend of increasing inflammatory infiltration with longer durations is evident. Duration of hospital stay did not significantly influence most histopathological changes, except for mild dermal congestion and lymphocytic infiltration, suggesting that some vascular and inflammatory features may evolve with survival time. Overall, our study confirms the heterogeneity of histopathological features in ligature marks, with household fabrics prominently associated with epidermal changes in female victims. Epidermal thinning and dermal compression were frequent, while inflammatory infiltration was relatively uncommon, corroborating previous

findings from Shoba et al., Jiwane et al., and Sahu et al., whose study population were brought dead cases with history of compression of neck. The variability in dermal congestion, edema, and haemorrhage emphasizes that microscopic findings are influenced by multiple factors, including ligature material, site placement, duration of compression, and survival period. However present study also has certain limitations like short duration study with very small sample size which collected from single centre also there was no control group and there was multiple histopathological variability with lack of clinical correlation. Hence, it is recommended to do further study using different methods like routine histopathological examination, histochemistry and immunohistochemistry on larger sample size, with other type of compression of neck and in comparison with the healing process of the other types of abrasions.

CONCLUSION

The present study demonstrates that females constituted the majority of delayed death due to hanging cases. Household fabrics such as dupatta and saree were the most frequently used materials, while metallic and plastic wires were less common which indicate that it was not an planned act. The Histopathological findings shows inconclusive epidermal and dermal changes, that is inflammatory responses of various permutation and combinations. A statistically significant association was noted between the type of ligature material and epidermal changes, particularly with dupatta and saree. While type of hanging and duration of hospital stay showed limited influence on most histopathological features. Clinical outcomes, including unconsciousness at presentation and the need for tracheostomy, underscore the severity of neurological compromise in hanging victims.

Overall, histopathological evaluation of ligature marks provides critical insights into duration of survival after injury, though it must be interpreted in conjunction with duration of suspension, type of ligature material and their composition, clinical history and scene findings to achieve accurate forensic conclusions.

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