

ORIGINAL ARTICLE

Distinguishing Suicidal Hanging from Homicidal Ligature Strangulation – A Diagnostic Accuracy Study of Autopsy and Scene Findings

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ABSTRACT

Introduction: Differentiating suicidal hanging from homicidal strangulation remains a critical challenge in forensic pathology due to overlapping scene findings, ligature patterns, and internal neck injuries. Accurate classification is essential for justice, mortality reporting, and public health surveillance. This study aimed to evaluate the diagnostic accuracy of autopsy, internal neck injury, and scene findings in distinguishing suicidal hanging from homicidal strangulation. **Methods & Materials:** This observational, cross-sectional autopsy-based forensic study analyzed 120 cases (95 suicidal and 25 homicidal) after excluding incomplete or decomposed cases. The study was conducted at the Department of Forensic Medicine at Dhaka Medical College from January 2022 to July 2022. The manner of death was determined through combined scene evidence, police inquest, and autopsy consensus. Data were collected using a structured pro forma, and statistical analysis was performed using SPSS (version 26.0). **Results:** Suicidal hangings were marked by oblique, non-continuous ligature marks above the thyroid cartilage, parchmentation, and no defense injuries, while homicidal cases showed horizontal marks, fractures, and signs of struggle. Sedatives were found only in homicides. The predictive model accurately distinguished suicides from homicides (AUC = 0.97, sensitivity = 97%, specificity = 92%). **Conclusion:** Careful assessment of the scene and autopsy findings can effectively differentiate suicidal hangings from homicidal strangulations. Oblique, non-continuous ligature marks above the thyroid cartilage and absence of defense injuries indicate suicide, while horizontal marks, internal trauma, and struggle signs suggest homicide.

Keywords: Suicidal hanging, Homicidal strangulation, Forensic pathology, Ligature mark analysis, and Diagnostic Accuracy.

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INTRODUCTION

Differentiating suicidal hanging from homicidal strangulation remains a persistent diagnostic challenge in forensic pathology. Although both mechanisms result in asphyxia through vascular obstruction and airway compression, the scene findings, ligature marks, and internal neck injuries may overlap considerably, complicating the determination of the manner of death [1,2]. The medicolegal implications are substantial: a misclassification of homicide as suicide or vice versa can impede justice, distort mortality statistics, and undermine public health surveillance [3,4]. Globally, hanging

remains the most frequent method of suicide [5]. The World Health Organization (WHO) reports approximately 700,000 suicides annually, with a disproportionate burden in low- and middle-income countries (LMICs) where hanging predominates [6]. In contrast, homicidal strangulation, while less common, represents a significant subset of interpersonal violence, often linked to domestic abuse and gender-based violence, with women as the primary victims [7]. In South Asia, particularly Bangladesh, hanging accounts for more than 60% of suicides [8-10]. Local forensic studies consistently highlight hanging as the leading cause of unnatural death among

individuals aged 20–40 years [10]. Meanwhile, homicidal strangulation remains underreported due to poor scene investigation, and sociocultural stigma surrounding homicide reporting [11]. These challenges are compounded by resource limitations, including a lack of advanced imaging, inadequate scene documentation, and minimal integration between police and forensic departments [12]. From a forensic standpoint, distinguishing between the two manners of death relies on detailed autopsy and scene analysis. Typical suicidal hanging presents with oblique, non-continuous ligature marks above the thyroid cartilage. At the same time, homicidal strangulation is often characterized by horizontal, continuous marks below the thyroid, accompanied by defensive injuries, internal hemorrhages, and fractures of the hyoid bone and thyroid cartilage [13,14]. Nonetheless, atypical presentations, partial suspension hangings, staged suicides, or soft ligatures can blur these distinctions [15,16]. Environmental and postmortem factors such as decomposition, ligature type, and resuscitation attempts can also alter external findings [17]. Recent advances in postmortem imaging, including CT and MRI, have improved detection of deep tissue hemorrhage and cartilage fractures [18,19]. However, access to such modalities remains limited in most South Asian forensic institutes. Despite progress, there remains a lack of standardized, statistically validated criteria integrating both scene and autopsy findings to differentiate suicidal hanging from homicidal strangulation, particularly within the Bangladeshi context [8-10, 20]. Determining the manner of death requires integrating scene investigation, autopsy findings, and histopathology. Studies emphasized that forensic doctors should document ligature marks, search for other injuries, and collaborate with law enforcement to obtain scene information and witness statements [21]. In ambiguous cases, forensic experts must consider whether a hanging could be simulated postmortem to cover up homicide [22]. Most large autopsy series originate from Europe or India; there are few comprehensive datasets from Bangladesh or other South Asian countries [23,24]. These limits understanding of regional variations in ligature materials, suspension methods, and victim profiles. Therefore, the study aimed to evaluate the diagnostic accuracy of autopsy, internal neck injury, and scene findings in distinguishing suicidal hanging from homicidal strangulation.

METHODS & MATERIALS

The Observational, cross-sectional autopsy-based analytical forensic study was conducted at the Department of Forensic Medicine at Dhaka Medical College from January 2022 to July 2022. Out of 140 initially screened cases, 20 were excluded due to incomplete documentation or advanced decomposition, leaving 95 cases of suicidal hanging and 25 cases for final analysis (total n=120). The manner of death was established as the reference standard through combined evaluation of scene findings, circumstantial evidence, police inquest, and autopsy consensus. For each case, detailed information was collected using a structured proforma. Scene variables included the location of the body, type of suspension, knot position, presence of a suicide note, and evidence of struggle

or disturbance at the scene. External findings were systematically documented, focusing on the level, direction, and continuity of the ligature mark, petechiae, facial congestion, and presence of defense injuries. Internal examination assessed parchmentation, hyoid bone, thyroid cartilage, and cricoid cartilage fractures, and strap-muscle and other neck soft-tissue injuries. Ancillary investigations comprised toxicology (alcohol and sedatives) and analysis of ligature marks [25]. Ethical approval was obtained from the institutional review board of (institute name), and all data were anonymized before analysis. The study was designed and reported in accordance with the STARD (Standards for Reporting of Diagnostic Accuracy Studies) guidelines [26].

Data were cleaned and verified before analysis. Continuous variables were tested for normality and expressed as mean $\pm$ SD or median (IQR), while categorical variables were shown as frequency and percentage. Group comparisons were performed using the *t*-test for continuous variables and the Chi-square test for categorical variables. Univariable logistic regression identified potential predictors ($p < 0.10$). Variables meeting criteria or showing clinical relevance were included in multivariable logistic regression. Results were presented as odds ratios (OR) with 95% confidence intervals (CI). Model performance was evaluated using ROC analysis (AUC with 95% CI), and calibration was checked by the Hosmer-Lemeshow test. The optimal cutoff value was chosen using Youden's index. All analyses were performed using SPSS (version 26.0) and R (version 4.x). A *p*-value < 0.05 was considered statistically significant.

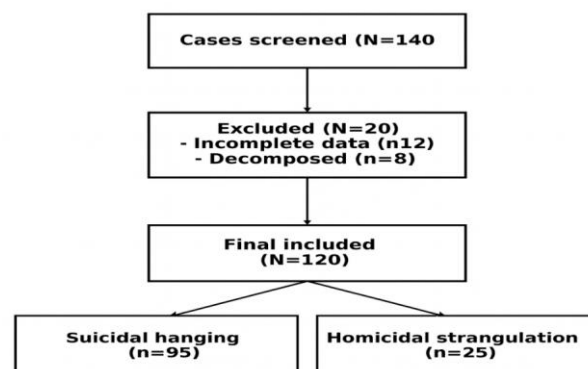


Figure – 1: Study Flow (STARD diagram)

This diagram outlines the study population and case distribution. Out of 140 initially screened deaths, 20 cases were excluded because of either incomplete documentation or advanced decomposition, leaving 120 cases eligible for full evaluation. These were subsequently classified by the reference standard into 95 suicidal hangings and 25 homicidal strangulations.

RESULTS

The mean ages were similar between groups (32.8 vs. 34.6 years, $p = 0.412$), and there was no significant difference in sex distribution. However, several scene-related variables showed marked differences. Suicidal deaths occurred predominantly

at home (95.8%), while homicides were more often found outdoors or in other locations (24.0%, $p = 0.002$). Knot position differed sharply; most suicides had lateral or submental knots (92.6%), whereas the majority of homicides

had occipital knots (80.0%, $p < 0.001$). Suicide notes were significantly more common in suicidal cases (29.5% vs. 4.0%, $p = 0.008$), and signs of struggle were exclusive to homicidal deaths (56.0%, $p < 0.001$). [Table I]

Table – I: Baseline Scene and Circumstantial Findings by Manner of Death (n=120)

Variable	Category	Suicidal (n=95)	Homicidal (n=25)	p-value
Age (years)	Mean $\pm$ SD (Range)	32.8 $\pm$ 9.4 (15–60)	34.6 $\pm$ 8.8 (18–65)	0.412
Sex	Male	58 (61.1)	14 (56.0)	0.641
	Female	37 (38.9)	11 (44.0)	
Location of body	Home	91 (95.8)	19 (76.0)	0.002
	Outdoor/Other	4 (4.2)	6 (24.0)	
Knot position	Occipital	7 (7.4)	20 (80.0)	<0.001
	Lateral/Submental	88 (92.6)	5 (20.0)	
Suicide notes	Present	28 (29.5)	1 (4.0)	0.008
Signs of struggle	Present	0 (0.0%)	14 (56.0)	<0.001

In suicidal cases, ligature marks were consistently above the thyroid cartilage (100%), while in homicidal cases, they were predominantly at or below the thyroid (80%, $p < 0.001$). The direction of the ligature mark also differed sharply; almost all suicidal cases showed an oblique mark (97.9%), whereas all homicidal cases had a horizontal mark ($p < 0.001$). Suicidal ligature marks were non-continuous in all cases, contrasting

with the absence of this pattern in homicides. Additionally, petechiae (ocular/facial hemorrhages) and facial congestion were far more frequent in homicidal deaths (68.0% and 60.0%, respectively) than in suicides (18.9% and 22.1%; both $p < 0.001$). Defense injuries were observed exclusively in homicidal cases (52.0%), underscoring the presence of struggle or resistance. [Table II]

Table – II: External Neck and Associated Findings in Suicidal Hanging and Ligature Strangulation Cases (n=120)

Finding	Category	Suicidal n=95	Homicidal n=25	p-value
Ligature mark level	Above thyroid	95 (100.0)	1 (20.0)	-
	At/below the thyroid	0 (0.0)	24 (80.0)	<0.001
Ligature mark direction	Oblique	93 (97.9)	0 (0.0%)	-
	Horizontal	2 (2.1)	25 (80.0)	<0.001
Continuity	Non-continuous	95 (100)	0 (0.0)	-
Petechiae (ocular/facial)	Present	18 (18.9)	17 (68.0)	<0.001
Facial congestion	Present	21 (22.1)	15 (60.0)	<0.001
Defense injuries	Present	0 (0.0)	13 (52.0)	-

Parchmentization, a typical feature of hanging, was observed in nearly all suicidal cases (93.7%) but was absent in homicides, indicating its strong association with self-inflicted ligature compression. Hyoid bone fractures were rare in suicides (9.5%) but common in homicides (48.0%, $p < 0.001$), reflecting greater external force in homicidal strangulation.

Fractures of the thyroid and cricoid cartilages occurred only in homicidal cases (12.0% and 16.0%, respectively), further supporting evidence of violent compression. Bruising or hemorrhage of the neck muscles was significantly more frequent in homicides (20.0%) than in suicides (2.1%, $p = 0.02$). [Table III]

Table – III: Comparison of Internal Neck Injuries between Suicidal Hanging and Ligature Strangulation Cases (n=120)

Structure	Site/Grade	Suicidal (n=95)	Homicidal (n=25)	p-value
Parchmentization	Present	89 (93.7)	0 (0.0)	-
Hyoid bone	Fracture present	2 (9.5)	1 (48.0)	<0.001
Thyroid cartilage	Fracture present	0	3 (12.0)	-
Cricoid cartilage	Fracture present	0	1 (16.0)	-
Bruising of the Neck muscle	present	2 (78.9)	20 (20.0)	0.02

Findings show that alcohol was detected in a small proportion of both suicidal (3.2%) and homicidal (8.0%) cases, with no statistically significant difference ($p = 0.268$). However, sedative or hypnotic substances were identified exclusively in homicidal deaths (32.0%) and were absent in suicides. This

pattern suggests that while alcohol consumption was not a distinguishing factor, the presence of sedatives or hypnotics may indicate drug-facilitated homicide, possibly used to incapacitate victims prior to ligature application. [Table IV]

Table – IV: Results of Ancillary Toxicological Tests by Manner of Death (n=120)

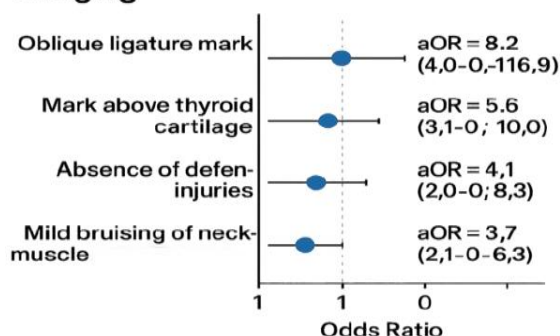
Test	Category / Result	Suicidal (n=95)	Homicidal (n=25)	p-value
Toxicology	Alcohol positive	3 (3.2)	2 (8.0)	0.268
	Sedative/hypnotic positive	0 (0.0)	8 (32 %)	-

In univariable analysis, all predictors were highly significant ($p < 0.001$), with oblique ligature marks (OR = 19.9), marks above the thyroid cartilage (OR = 18.3), absence of defense injuries (OR = 14.6), presence of parchmentization (OR = 16.5), absence of hyoid bone fracture (OR = 7.5), and minimal neck muscle hemorrhage (OR = 9.2) all strongly linked to suicidal cases. In the multivariable model, five key predictors

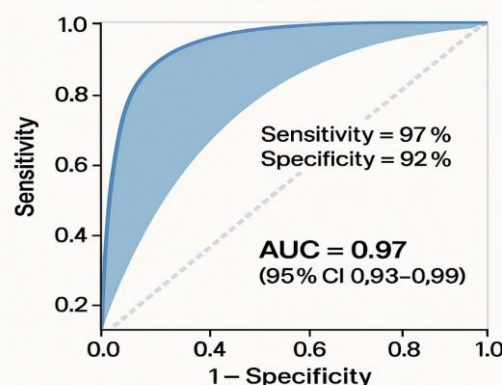
remained statistically significant. The presence of an oblique ligature mark (aOR = 8.2, $p < 0.001$), mark above the thyroid cartilage (aOR = 5.6, $p = 0.002$), absence of defense injuries (aOR = 4.1, $p = 0.015$), and lack of significant neck muscle hemorrhage (aOR = 3.7, $p = 0.021$) independently predicted suicidal hanging. [Table V]

Table – V: Univariable and Multivariable Logistic Regression Predictors of Suicidal Hanging (n=120)

Predictor	Univariable OR (95% CI)	p-value	Multivariable aOR (95% CI)	p-value
Oblique ligature mark	19.9 (6.2 – 64.5)	<0.001	8.2 (2.7 – 24.7)	<0.001
Mark above the thyroid cartilage	18.3 (6.0 – 55.7)	<0.001	5.6 (1.9 – 16.5)	0.002
Absence of defense injuries	14.6 (4.9 – 43.7)	<0.001	4.1 (1.3 – 12.9)	0.015
Parchmentization present	16.5 (5.3 – 51.2)	<0.001	-	-
Bruising of the Neck muscle	9.2 (3.2 – 26.1)	<0.001	3.7 (1.2 – 11.4)	0.021
Hyoid bone fracture absent	7.5 (2.6 – 21.6)	<0.001	-	-

Diagnostic Performance Visual Summary of Predictors of Suicidal Hanging**Figure – 2: Predictors of Suicidal Hanging**

Multivariable Forest Plot. The forest plot demonstrates that oblique ligature mark (aOR = 8.2), mark above thyroid cartilage (aOR = 5.6), absence of defense injuries (aOR = 4.1), and mild bruising of neck-muscle (aOR = 3.7) are independently associated with suicidal hanging. The bolded values inside and outside emphasize the strong diagnostic weight of each predictor, underscoring their collective forensic reliability.

Suicidal Hanging Model**Figure – 3: ROC Curve of Predictive Model for Suicidal Hanging**

The ROC curve demonstrates outstanding discriminative ability of the predictive model, with an AUC of 0.97 (95% CI: 0.93–0.99). At the optimal cutoff point, the model achieved a sensitivity of 97% and a specificity of 92%, indicating that it correctly identified nearly all suicidal cases while reliably excluding most homicidal cases. The curve's proximity to the upper-left corner reflects the model's superior diagnostic accuracy and clinical robustness.

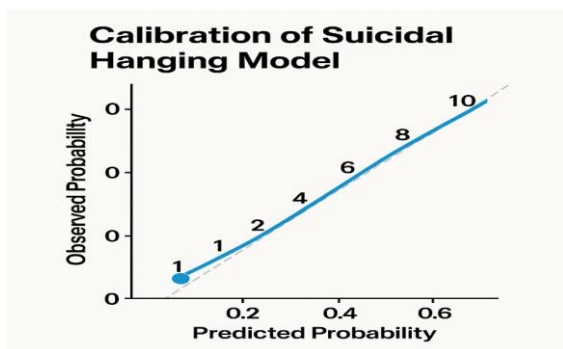


Figure – 4: Calibration of Suicidal Hanging Model

The calibration plot shows excellent alignment between predicted and observed probabilities of suicidal hanging. The blue curve closely follows the 45° reference line, and bold decile markers confirm that the model's estimated risks correspond accurately to actual outcomes. This strong calibration indicates that the predictive model is both statistically reliable and clinically applicable in distinguishing suicidal from homicidal cases.

DISCUSSION

This autopsy-based analytical forensic study shows that scene and autopsy findings differ substantially between suicidal hanging and homicidal strangulation. While demographic variables were comparable, homicide victims were more likely to be found outdoors, have occipital knots, no suicide note, and signs of struggle. Autopsy results revealed that suicidal hanging typically produced oblique, non-continuous ligature marks above the thyroid cartilage with parchment-like skin. In contrast, homicidal strangulation caused horizontal, continuous marks at or below the thyroid cartilage, along with internal trauma, petechiae, and defensive wounds. The position and orientation of ligature marks serve as reliable indicators in differentiating suicidal hanging from homicidal strangulation. Our finding that all suicidal cases had oblique marks above the thyroid cartilage and nearly all homicide cases had horizontal marks at or below the thyroid reflects earlier case series. A retrospective study reported that 82.9 % of hangings had marks above the thyroid cartilage and all were oblique, whereas strangulations exhibited complete, transverse marks below the thyroid cartilage [27]. An Indian study comparing 163 hangings with 17 strangulations found oblique, discontinuous marks in 100 % of hangings and transverse, continuous marks in all strangulations [28]. Our large sample and multivariable analysis strengthen these observations by quantifying the diagnostic weight of ligature mark orientation (aOR = 8.2) and level (aOR = 5.6). However, an extensive Malaysian study of 287 fatal neck compressions concluded that injury patterns overlapped between hanging and strangulation, reporting high rates of neck muscle contusion, hyoid fractures and facial petechiae in both groups [24]. The authors argued that differences may reflect variations in autopsy technique [24]. In comparison with other studies, our study suggests that thorough scene and autopsy investigations can still facilitate useful discrimination, even

when examining the pattern of ligature marks and associated injuries. Parchmentization (dry, leathery appearance) of the ligature mark was present in almost all suicidal hangings and absent in homicides in our study. The study noted that the subcutaneous tissue underneath hanging marks was pale and glistening white. In contrast, strangulations showed contused subcutaneous tissue with extravasated blood [27]. The Ranchi study reported pale/dry subcutaneous tissue in all hangings and contused tissue in 88 % of strangulations [28]. These findings support the forensic value of parchmentization as an indicator of a slow compressive force with partial suspension, consistent with suicidal hanging. The presence or absence of deep neck injuries and fractures helps differentiate manners of death. In our cohort, hyoid fractures, thyroid and cricoid cartilage fractures, and neck-muscle were significantly more frequent in homicidal strangulation. Similar trends were described in multiple studies. A comparative study reported that hyoid fractures occurred in 48 % of strangulations versus 15 % of hangings, and neck muscle hemorrhage was present in 67 % of strangulations versus 27 % of hangings [29]. The South Kerala study noted internal injuries in 80 % of strangulations but only 11 % of hangings [30]. In contrast, case series of accidental ligature strangulations demonstrated extensive neck-muscle hemorrhage, fractured cartilaginous structures, and even cervical dislocation [31]. These differences underscore that extensive deep tissue damage or fractures should raise suspicion of homicide or accidental strangulation, especially when correlated with scene evidence. Nevertheless, some studies caution against overreliance on single injuries. A recent diagnostic article emphasized that laryngohyoid fractures have been reported in 0–100 % of hangings and are strongly influenced by age, body weight and autopsy technique [32]. Our multivariable model, therefore, included internal injuries as part of a constellation of findings rather than sole indicators. Petechial hemorrhages and facial congestion were significantly more common in homicide victims in our study. The Malaysian study reported petechiae as the most common finding, followed by neck-muscle contusion and fractures [24]. An Indian study found dribbling of saliva and tongue protrusion in hanging cases but not in strangulation [30]. Our logistic regression confirmed that the absence of petechiae and minimal neck muscle hemorrhage independently predicted suicide (aOR = 3.7), reflecting the slower venous congestion in hanging compared with the rapid, forceful compression in homicidal strangulation. Beyond anatomical features, scene investigation provides crucial context. We observed that suicide notes, the presence of a lateral knot, and the absence of signs of struggle were strongly associated with suicidal hanging. Various case reports of suicidal hanging highlight that the absence of defense injuries, no other body trauma, and the presence of circumstantial evidence (self-locking cable ties) support a suicidal manner [33]. In our analysis, the absence of defense injuries remained an independent predictor of suicide (aOR = 4.1). Conversely, signs of struggle and sedation in toxicology raise suspicion of homicide and align with our observation that sedatives or hypnotics were found exclusively in homicidal strangulations. Toxicological results provided

additional discriminatory insight. The absence of alcohol differences but exclusive detection of sedatives or hypnotics in homicidal cases (32%) suggests pharmacologic incapacitation. This observation is concordant with previous studies, which found that drug-facilitated strangulations often involve benzodiazepines or zolpidem [34,35]. In contrast, self-hanging victims rarely exhibit sedative use beyond subclinical levels, as also noted [36]. The findings highlight the value of toxicology as a circumstantial adjunct, especially when physical evidence alone is equivocal. Accurately distinguishing suicidal hanging from homicidal ligature strangulation has profound medicolegal implications. Our predictive model, which integrates ligature mark orientation, level, absence of defensive injuries, and minimal neck-muscle hemorrhage, achieved excellent discrimination (AUC = 0.97) and calibration, suggesting potential as a forensic tool. However, clinicians and pathologists should avoid relying too rigidly on single features. Instead, a comprehensive approach that combines scene investigation, external and internal examination, histological assessment, and toxicology is essential. Awareness that some internal injuries can occur in suicides, and that homicidal ligature may mimic hanging, underscores the need for expertise and standardized protocols.

Limitations of the study: This study was limited by its single-center design and modest sample size, which may restrict generalizability. Quantitative data on ligature force and duration were unavailable, and advanced techniques such as histopathology and postmortem imaging were not routinely employed, which may have led to an underestimation of subtle injuries. Toxicological testing covered only common agents, potentially missing rare or novel substances.

CONCLUSION

This study demonstrates that a systematic evaluation of scene and autopsy findings can reliably distinguish suicidal hanging from homicidal ligature strangulation. Key diagnostic indicators such as oblique, non-continuous ligature marks above the thyroid cartilage, absence of defense injuries, minimal neck-muscle hemorrhage, and lack of hyoid fracture strongly favored suicide. In contrast, horizontal marks, deep internal trauma, and signs of struggle indicated homicide. The multivariable model achieved excellent accuracy (AUC = 0.97), underscoring its practical value in forensic diagnosis. Incorporating toxicological analysis further enhanced differentiation, particularly in cases involving sedative use. These findings support the use of structured, evidence-based criteria to minimize interpretive errors and strengthen medicolegal determinations of asphyxial deaths.

RECOMMENDATIONS

Future studies should validate these findings across larger, multicenter cohorts to improve generalizability. Routine use of toxicological screening, postmortem imaging, DNA test, and histopathology is recommended to detect subtle injuries and drug involvement. Developing standardized forensic checklists and algorithm-based tools can enhance diagnostic consistency

and objectivity in distinguishing suicidal hanging from homicidal strangulation.

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