

Review Article

Forensic Investigation of Hanging Cases: A Comprehensive Review of Scene Examination, Autopsy Findings, Differential Diagnosis and Modern Forensic Approaches

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ABSTRACT:

Hanging is a form of mechanical asphyxia in which compression of the neck by a ligature occurs under the influence of the body weight or a portion of the body weight. Although hanging is frequently encountered in forensic practice, determination of the cause and manner of death may be challenging, particularly in cases involving partial suspension, atypical ligature marks, decomposition, intoxication, or associated traumatic injuries. A reliable forensic investigation requires systematic documentation of the scene, examination of the suspension mechanism and ligature, detailed external and internal examination at autopsy, appropriate toxicological and histopathological investigations, and correlation with investigative information. The presence, morphology, and distribution of a ligature mark should not be interpreted in isolation. Modern approaches involving postmortem computed tomography, digital photography, three-dimensional documentation, molecular and biochemical investigations, and advanced toxicology may provide additional information in selected cases. This review summarizes the major forensic principles involved in the investigation of hanging cases, discusses the interpretation of scene and autopsy findings, highlights important differential diagnoses, and examines emerging technologies that may improve the accuracy and reproducibility of forensic opinions.

Keywords: Hanging; forensic pathology; mechanical asphyxia; ligature mark; neck compression; autopsy; forensic toxicology; postmortem imaging; forensic investigation; manner of death.

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1. INTRODUCTION:

Hanging represents an important form of mechanical asphyxia encountered in forensic medicine. It results from compression of the neck by a ligature associated with suspension of the body. The mechanism may involve obstruction of the airway, impairment of venous return, arterial compromise, stimulation or inhibition of reflex pathways, and combinations of these mechanisms [1–3].

From a forensic perspective, hanging is not simply an autopsy diagnosis. The interpretation of a hanging death requires integration of information obtained from the scene, the body, the ligature, toxicological examination, histopathology, and the circumstances reported by investigating authorities [1,4,5].

One of the major challenges is determination of the manner of death. A case may be suicidal, accidental, or, less commonly, homicidal or associated with another mechanism of neck compression. Therefore, the forensic expert should avoid relying on a single feature such as the ligature mark, knot position, facial appearance, or presence/absence of a neck fracture [4–7]. In particular, recent meta-analytic evidence indicates that cervical and laryngohyoid fractures show substantial variability and should not be given independent weight in determining the manner of a hanging death [6].

A comprehensive forensic investigation should answer several questions:

1. Is the death consistent with hanging?
2. What mechanism caused death?
3. Are there injuries unrelated to the hanging?

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4. Is there evidence of struggle, restraint, or assault?
5. What role did alcohol, drugs, or other substances play?
6. Is the scene consistent with the proposed history?
7. What is the most appropriate forensic opinion regarding cause and manner of death?

These questions should be addressed through correlation of the scene examination, ligature characteristics, external and internal autopsy findings, laboratory investigations, toxicology, and investigative circumstances [1,4,5].

2. CLASSIFICATION OF HANGING:

Hanging may be classified according to several criteria [1,2].

2.1 Complete and incomplete hanging

Complete hanging

The entire body is suspended and does not substantially contact the ground or another supporting surface [1,2].

Partial or incomplete hanging

A portion of the body remains supported by the floor, furniture, wall, or another object [1,2,8].

Importantly, partial suspension does not exclude fatal hanging. Compression of the neck may occur even when only part of the body weight acts through the ligature. Prospective forensic studies have specifically included both complete and partial suspension when evaluating hanging-related neck injuries, demonstrating that partial suspension is an important category in forensic investigation [8].

2.2 Typical and atypical hanging

Classification may also consider the position of the knot and the resulting distribution of pressure around the neck [1,2,8]. A typical pattern traditionally refers to a knot positioned posteriorly, whereas atypical patterns involve other knot positions [1,2]. However, the knot position should not be used independently to determine the manner of death [6,8]. Research has demonstrated associations between knot position and the distribution of laryngohyoid injuries, but these findings are not sufficiently specific to establish the manner of death in isolation [6,8].

3. SCENE INVESTIGATION

Scene examination is one of the most important components of a hanging investigation [9–11].

The forensic team should document the scene systematically before disturbing the body or ligature [9,10].

3.1 Scene documentation

The following should be recorded:

- Exact location of the body [9,10]
- Body position and orientation [9,10]
- Degree of suspension [9,11]
- Contact with the floor or surrounding objects [9,11]
- Suspension point [9,10]
- Ligature material [9,12]
- Knot position and configuration [10,12]
- Clothing [9,10]
- Footwear [9,10]
- Nearby furniture or objects [9,10]
- Blood or biological stains [9,10]
- Signs of disturbance [9,10]
- Potential evidence of struggle [9,11]
- Environmental conditions [9,10]

Photographs should include overall, mid-range, and close-up views to preserve the spatial relationship between the body, ligature, suspension point, and surrounding environment [9,10].

4. EXAMINATION OF THE SUSPENSION POINT:

The suspension point should be carefully documented [9,10].

Important observations include:

- Type of supporting structure [9,10]
- Height and accessibility [9,10]
- Strength and stability of the attachment point [9,10]
- Position of the ligature [10,12]
- Presence of abrasion or deformation [9,12]
- Compatibility between the ligature and suspension point [10,12]

The physical relationship between the body, ligature, knot, and suspension point should be assessed as part of scene reconstruction [9–12].

The accessibility and configuration of the suspension point may be particularly important when evaluating whether the observed scene is consistent with the reported circumstances [9,11].

5. EXAMINATION OF THE LIGATURE:

The ligature is an important piece of physical evidence in suspected hanging and should be documented and preserved carefully [10,12,13].

The forensic investigator should document:

- Material [10,12]
- Construction [12,13]
- Width [12,13]
- Thickness [12,13]
- Texture [12,13]
- Length [10,12]
- Knot type [10,12]
- Number of knots [10,12]
- Knot position [10,12,14]
- Areas of compression [12,13]
- Fibres or other trace material [12,13]
- Damage or deformation [10,12]

The ligature should be preserved carefully to avoid destroying potentially valuable trace evidence or altering the original knot configuration [10,12,13].

Where appropriate, forensic laboratory examination may include:

- Fibre analysis [13]
- DNA examination [13,15]
- Trace evidence analysis [13,15]
- Comparison with material recovered from the scene [12,13]
- Examination for biological material [13,15]

The characteristics of the ligature may also influence the appearance of the ligature mark and the pattern of underlying neck injury [12,14].

6. EXAMINATION OF THE BODY AT THE SCENE:

Before removal, the body should be documented extensively in its original position [9–11].

Important observations include:

- Position of head [9,10]
- Position of limbs [9,10]
- Clothing [9,10]
- State of suspension [9,11]
- Ligature position [10,12]
- Knot position [10,14]
- Salivary dribbling [9,11]
- Facial appearance [9,11]
- Visible injuries [9,10]

- Blood or other biological material [9,10]
- Signs of disturbance [9,10]

The body should preferably be photographed from multiple angles, including overall views and detailed views of the neck, ligature, knot, clothing, visible injuries, and relevant surrounding evidence [9,10].

7. LIGATURE MARK

The ligature mark is one of the most important findings in suspected hanging [16–18]. It should be described systematically rather than simply recorded as “ligature mark present” [16,17].

7.1 Features to document

The following characteristics should be documented:

- Anatomical level [16,17]
- Circumference and distribution [16,17]
- Width [16,17]
- Depth [16,17]
- Color [16,18]
- Dryness [16,18]
- Texture [16,18]
- Direction [16,17]
- Continuity [16,17]
- Areas of interruption [16,17]
- Associated abrasions [16–18]
- Associated bruising [17,18]
- Relationship to the ligature [16,17]

The appearance may vary depending on:

- Type of ligature [16,17]
- Duration of suspension [16,18]
- Tightness [16,17]
- Body position [17,18]
- Material characteristics [16,17]
- Movement of the body [17]
- Postmortem changes [16,18]

Therefore, the morphology of the mark should always be interpreted in context and correlated with the scene, ligature characteristics, autopsy findings and other investigative information [16–19].

Histological and immunohistochemical examination may provide supplementary information regarding the vitality of a ligature mark, particularly when differentiation between antemortem and postmortem injury is required [18].

8. EXTERNAL AUTOPSY EXAMINATION

A complete external examination should include the entire body rather than focusing exclusively on the neck [19–21].

The forensic pathologist should document:

Head and face

- Facial congestion or pallor [19,20]
- Petechial hemorrhages [19,20]
- Cyanosis [19,20]
- Oral and nasal findings [19,20]
- Salivary dribbling [19,20]

Neck

- Ligature mark [16,19]
- Abrasions [17,19]
- Bruising [17,19]
- Swelling [19,20]
- Other injuries [19–21]

Body

- Defensive-type injuries [19–21]
- Contusions [19–21]
- Abrasions [19–21]
- Lacerations [19–21]
- Injuries suggestive of restraint or assault [20,21]

The absence of external injuries does not by itself establish suicide; the forensic interpretation should be based on the complete scene and autopsy findings [19–21]. Comparative autopsy studies show that hanging and strangulation can have overlapping external and internal findings, making comprehensive examination essential.

9. INTERNAL EXAMINATION OF THE NECK

Internal neck examination is an essential component of forensic autopsy in suspected hanging [19,22,23].

Structures that may require examination include:

- Skin and subcutaneous tissues [22,23]
- Platysma [22,23]
- Strap muscles [22,23]
- Hyoid bone [22–24]
- Thyroid cartilage [22–24]
- Cricoid cartilage [22,23]
- Laryngeal structures [22–24]
- Cervical soft tissues [22,23]
- Blood vessels where indicated [22,23]

Hemorrhage within soft tissues may provide evidence of neck injury, but its significance must be interpreted together with the complete case rather

than as an isolated indicator of manner of death [22,23].

Importantly, the technique used for neck dissection can influence the detection of injuries. Recent evidence suggests that a systematic layered neck dissection may increase the detection of neck-muscle bruising and laryngohyoid fractures [23].

10. FRACTURES OF THE HYOID BONE AND LARYNGEAL CARTILAGES

Fractures of the hyoid bone or laryngeal cartilages may occur in hanging, but their presence or absence should not be regarded as an absolute diagnostic criterion [24–27].

Factors influencing fracture frequency include:

- Age [24–27]
- Degree of ossification [24,25]
- Bone fragility [24,25]
- Mechanism of neck compression [24–26]
- Force applied [24,25]
- Individual anatomical variation [24,25]

Recent studies demonstrate considerable variability in the frequency of laryngohyoid fractures among hanging cases. The interpretation therefore requires consideration of age, knot position, ligature characteristics and the overall autopsy findings [24–27].

Thus:

Fracture present ≠ automatically homicidal hanging
and

Fracture absent ≠ exclusion of hanging [24–27].

A 2024 machine-learning study further demonstrated that fracture patterns may contain information regarding knot position, but such approaches should be considered supportive rather than independently determinative of the manner of death [27].

11. HISTOPATHOLOGICAL EXAMINATION

Histopathology may be useful in selected cases [18,28].

Possible specimens include:

- Ligature-mark tissue [18,28]
- Underlying soft tissue [18,28]
- Neck muscles [22,28]
- Skin [18,28]
- Other suspicious injury sites [28]

Microscopic examination may assist in assessing tissue injury and hemorrhage, although histological findings should not be interpreted as a standalone “test for hanging” [18,28].

Immunohistochemical investigations have been explored for assessment of vitality and age of ligature marks. However, the literature indicates variability in the markers used and the absence of complete consensus regarding a single reliable immunohistochemical marker panel [18].

12. FORENSIC TOXICOLOGY

Toxicological examination can be particularly important because alcohol, medications, recreational drugs, or other substances may influence:

- Consciousness [29]
- Judgment [29]
- Motor coordination [29]
- Ability to resist [29]
- Behaviour before death [29]
- Ability to escape from a dangerous situation [29]

Appropriate specimens may include:

- Peripheral blood [29,30]
- Urine [29,30]
- Vitreous humor [29,30]
- Gastric contents [29,30]
- Liver or other tissues where appropriate [29,30]

The toxicological results should be interpreted in conjunction with postmortem findings and investigative information rather than being considered independently [29,30].

13. DIFFERENTIAL DIAGNOSIS

A forensic examination should consider other forms of neck compression [19,20,31].

Important differential considerations include:

13.1 Hanging

Neck compression associated with suspension by a ligature [19,31].

13.2 Ligature strangulation

Compression of the neck by a ligature without suspension by body weight [19,31].

13.3 Manual strangulation

Compression of the neck using hands, fingers, or other parts of the body [19,31].

13.4 Accidental neck compression

Neck compression associated with an accidental mechanism [19,20].

13.5 Postmortem simulation

A situation in which a body is suspended after death to create an apparent hanging scene [19,20,32].

The distinction requires integration of scene, autopsy, toxicology, and investigative findings [19,20,31,32]. Comparative forensic studies emphasize that hanging and strangulation can show overlapping findings, so no isolated feature should be used as the sole basis for differentiation.

14. SUICIDE VERSUS HOMICIDE

One of the most difficult forensic questions is determining whether a hanging was suicidal or resulted from another circumstance [19,20,32].

No single finding should be considered conclusive [19,20,32].

The forensic expert should evaluate:

- Scene reconstruction [19,20]
- Accessibility of suspension point [19,20]
- Ligature characteristics [16,17]
- Knot configuration [17,27]
- Body position [19,20]
- Clothing [19,20]
- Associated injuries [19–21]
- Evidence of restraint [20,32]
- Evidence of struggle [20,32]
- Toxicology [29,30]
- Witness statements [20,32]
- Circumstantial evidence [19,20,32]
- Digital and electronic evidence where legally available [33,34]

The forensic opinion should clearly distinguish medical cause of death from manner of death [19,20].

15. ROLE OF DIGITAL AND ELECTRONIC EVIDENCE

Modern forensic investigations increasingly involve digital information, particularly in cases where investigators need to reconstruct events preceding an unexplained or suspected suicide [33,34].

Where legally obtained and relevant, investigators may examine:

- Mobile-phone records [33,34]
- Messages [33,34]
- Emails [33,34]

- Social-media activity [33,34]
- CCTV footage [33,35]
- Location information [33,35]
- Digital photographs [33,34]
- Search history [33,34]
- Relevant electronic communications [33,34]

Such evidence should be interpreted carefully and integrated with physical and medical findings rather than replacing forensic examination [33–35]. Digital evidence can provide contextual information about communications, chronology and activities, but its evidentiary value depends on proper acquisition, preservation, authentication and interpretation.

16. POSTMORTEM IMAGING

Postmortem imaging can complement conventional autopsy and has become an increasingly important component of modern forensic practice [36–38].

Postmortem CT

PMCT may assist in identifying:

- Skeletal injuries [36,37]
- Foreign material [36,38]
- Fractures [36–38]
- Anatomical abnormalities [36,38]
- Gas distribution [37]
- Other traumatic findings [36–38]

Three-dimensional reconstruction may also assist in documenting complex findings and communicating forensic imaging findings [39].

In cases of hanging, PMCT can provide useful information concerning laryngo-hyoid fractures and other neck findings. However, comparative studies indicate that PMCT does not detect all findings identified by conventional autopsy [36,37].

However, imaging should generally be regarded as complementary to, rather than a universal replacement for, conventional autopsy [36–38]. A systematic review of PMCT for hyoid-laryngeal fractures concluded that its diagnostic performance varies considerably and that PMCT cannot currently replace autopsy for assessment of these injuries [37]. Postmortem MRI may provide additional information regarding soft-tissue injuries and hemorrhage, although CT remains particularly useful for fracture assessment [38].

17. PHOTOGRAPHY AND 3D DOCUMENTATION

High-resolution photography is essential for forensic documentation and preservation of the appearance and spatial relationships of evidence [40,41].

Modern approaches may include:

- Standardized digital photography [40,41]
- Macro photography of ligature marks [40]
- Scaled photography [40,41]
- Three-dimensional surface documentation [39,42]
- Digital scene reconstruction [42]

Three-dimensional post-processing of forensic imaging can provide photorealistic visualization of complex anatomical and traumatic findings and may assist in forensic investigation, communication of findings and courtroom presentation [39].

Standardization may improve reproducibility between investigators and facilitate later review [40–42].

18. RECONSTRUCTION OF THE HANGING EVENT

Scene reconstruction attempts to determine whether the physical environment is compatible with the reported circumstances [40,43].

Relevant questions include:

1. Could the individual physically access the suspension point?
2. Is the ligature compatible with the observed mark?
3. Is the knot consistent with the scene?
4. Does the body position correspond with the physical environment?
5. Are injuries compatible with the proposed mechanism?
6. Is there evidence suggesting another mechanism?
7. Are toxicological findings relevant to the circumstances?

These questions should be evaluated through correlation of scene documentation, ligature characteristics, body position, autopsy findings and laboratory results [40,43,44].

Reconstruction should remain evidence-based and avoid assumptions that cannot be supported by physical evidence [40,43].

19. FORENSIC INTERPRETATION FRAMEWORK

A useful conceptual framework is:

Scene → Ligature → Body → Autopsy → Laboratory → Toxicology → Reconstruction → Integrated Opinion

Each component contributes independent information [40,43,44].

The final opinion should be based on the totality of evidence, rather than on any isolated autopsy or scene finding [43–45].

In particular, imaging, toxicology, histopathology and digital evidence should be interpreted as complementary components within the overall forensic investigation [36,38,44].

20. COMMON ERRORS IN HANGING INVESTIGATION

Several interpretative errors should be avoided [43–45].

Error 1: Considering every hanging suicidal

A hanging scene does not automatically establish suicide. Determination of manner requires integration of scene, autopsy and investigative information [43,44].

Error 2: Relying exclusively on the ligature mark

The mark must be correlated with the complete examination, including the ligature, scene and internal neck findings [16,43].

Error 3: Treating a hyoid fracture as proof of homicide

Fractures may occur in different circumstances and must be interpreted in context. Their presence or absence alone cannot establish the manner of death [22–27].

Error 4: Ignoring partial suspension

Partial suspension can still produce fatal neck compression and should not be excluded from consideration merely because the body is not completely suspended [1,2,43].

Error 5: Inadequate scene documentation

Poor documentation may prevent later reconstruction and limit interpretation of the relationship between the body, ligature and suspension point [40,43].

Error 6: Ignoring toxicology

Substances may significantly affect consciousness, behaviour, coordination and interpretation of the circumstances surrounding death [29,44].

Error 7: Failing to examine the entire body

Associated injuries may provide important evidence concerning the circumstances and possible mechanism of death [19–21,43].

21. Recommended Forensic Investigation Workflow

Stage	Major examination
Scene	Photograph and document complete scene [40,43]
Body position	Document suspension and contact points [40,43]
Suspension point	Examine attachment and accessibility [40,43]
Ligature	Document material, configuration and condition [16,17]
Body	Complete external examination [19–21]
Neck	Detailed ligature-mark examination [16–18]
Autopsy	Internal examination of neck and body [22–25]
Laboratory	Histopathology and trace examination where indicated [18,28]
Toxicology	Alcohol, drugs and relevant substances [29,30]
Imaging	PMCT/other imaging when indicated [36–39]
Reconstruction	Correlate physical evidence [40,43]
Interpretation	Establish cause and manner using totality of evidence [43–45]
Reporting	Prepare objective forensic opinion [43,44]

22. Future Directions

The future of hanging investigation is likely to involve greater integration of conventional forensic pathology with advanced technologies [39,46–48].

Potential areas include:

- Artificial intelligence-assisted image analysis [46–48]
- Three-dimensional scene reconstruction [39,42]
- Advanced postmortem imaging [36–39]
- Digital wound/ligature-mark documentation [40,42]
- Improved toxicological screening [29,30]
- Molecular and biochemical markers [18,28]
- Automated forensic documentation [46,47]
- Multidisciplinary forensic databases [46–48]

Recent reviews indicate that AI applications in forensic pathology and imaging are promising, but many remain experimental and are limited by small datasets, bias, lack of external validation and issues concerning transparency and medicolegal admissibility [46–48].

However, emerging technologies should be validated before being used as independent diagnostic tools [46–48]. Current evidence supports their use primarily as **complementary tools rather than replacements for forensic experts**.

23. Conclusion

The forensic investigation of hanging is a multidisciplinary process requiring careful scene examination, preservation of physical evidence,

detailed autopsy, appropriate laboratory investigations, and comprehensive reconstruction of the circumstances of death [43–45].

The ligature mark remains an important finding, but it should never be interpreted in isolation [16–18,43]. Similarly, the presence or absence of fractures of the hyoid bone or laryngeal cartilages cannot independently establish the manner of death [22–27].

A scientifically defensible forensic opinion should integrate scene findings, ligature characteristics, external and internal injuries, toxicology, histopathology, imaging, and investigative information [36,43–45].

Standardized documentation and modern technologies such as postmortem imaging and three-dimensional reconstruction may further improve the quality and reproducibility of forensic investigations [39,42,46]. Ultimately, careful evidence-based interpretation remains the foundation for distinguishing hanging from other forms of neck compression and for assisting the justice system in determining the circumstances surrounding death [43–48].

NOTES

All authors declare no competing financial interests.

CONFLICTS OF INTEREST

There are no conflicts to declare.

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Table 1. Classification of Hanging

Classification	Definition / Description	Important forensic consideration	References
Complete hanging	Entire body is suspended and does not substantially contact a supporting surface.	Degree of suspension should be documented at the scene.	[1,2,9]
Partial / incomplete hanging	Part of the body remains supported by the floor, furniture, wall, or another object.	Partial suspension does not exclude fatal hanging.	[1,2,8,43]
Typical hanging	Traditionally describes a posteriorly positioned knot with characteristic pressure distribution.	Knot position should not independently determine manner of death.	[1,2,8]

Atypical hanging	Knot is positioned away from the traditionally defined posterior location.	Scene reconstruction and complete autopsy remain essential.	[1,2,8]
Suicidal hanging	Hanging associated with self-inflicted suspension.	Determination requires integration of scene, autopsy and investigative evidence.	[19,20,43]
Accidental hanging	Hanging occurring through an unintended mechanism.	Circumstances and scene reconstruction are particularly important.	[19,20]
Homicidal / staged hanging	Hanging associated with homicide or postmortem simulation.	Cannot be established from ligature mark or knot position alone.	[19,20,32,43]

Table 2. Scene Findings to Be Documented

Scene component	Findings to document	Forensic significance	References
Body location	Exact location, orientation and position	Establishes original scene configuration	[9,10,40]
Degree of suspension	Complete or partial suspension	Important for reconstruction	[1,2,43]
Body-surface relationship	Contact with floor, furniture or wall	Helps reconstruct suspension mechanism	[9,10,40]
Suspension point	Type, height, accessibility and condition	Assesses compatibility with proposed mechanism	[9,10,43]
Ligature	Material, width, length, construction and condition	May correlate with ligature mark and trace evidence	[12,16,17]
Knot	Position, configuration and number of knots	Useful for scene reconstruction	[10,12,27]
Clothing	Condition and displacement	May reveal disturbance or associated injuries	[9,10]
Surroundings	Furniture, objects and possible access route	Helps reconstruct events	[9,10,40]
Biological evidence	Blood, saliva and other biological material	May provide corroborative evidence	[9,10,13]
Signs of disturbance	Displaced objects, damaged items, unusual scene features	May indicate struggle or alternative circumstances	[19,20]
Photography	Overall, mid-range and close-up photographs	Preserves spatial relationships for later review	[9,10,40]

Table 3. Characteristics of Ligature Marks

Feature	Description / Assessment	Interpretation
Anatomical level	Position of mark on neck	Should be correlated with ligature and body position [16,17]
Direction	Oblique, horizontal or other configuration	Morphology may vary with suspension circumstances [16,17]
Continuity	Continuous or interrupted	Document all areas of interruption [16,17]
Width	Measure the width where possible	May reflect characteristics of ligature [16,17]
Depth	Degree of indentation	Should be interpreted with ligature characteristics [16,18]
Color	Pale, reddish, brownish or other appearance	Influenced by tissue changes and postmortem processes [16,18]
Dryness	Dry, parchment-like or other appearance	May occur due to compression and drying [16,18]

Texture	Hardening, abrasion or surface alteration	May reflect ligature material [16–18]
Associated abrasion	Abrasions or excoriations around mark	Provides additional injury information [16–18]
Bruising	Subcutaneous or adjacent bruising	Requires correlation with internal findings [17,18]
Ligature correlation	Comparison with actual ligature	Important for scene reconstruction [16,17]

Table 4. External and Internal Autopsy Findings

Examination area	Possible findings	Forensic significance
Face	Pallor/congestion, petechiae, cyanosis	Supportive but nonspecific findings [19,20]
Eyes	Petechial hemorrhages and other ocular findings	Should be interpreted with other findings [19,20]
Mouth/nose	Salivary dribbling and other findings	May provide supportive scene/autopsy information [19,20]
Neck skin	Ligature mark, abrasions, bruising	Major component of external examination [16–19]
Subcutaneous tissue	Hemorrhage or tissue injury	Requires correlation with other findings [22,23]
Neck muscles	Hemorrhage or bruising	May support antemortem neck injury [22,23]
Hyoid bone	Fracture or intact bone	Fracture is neither necessary nor independently diagnostic [22–27]
Thyroid cartilage	Fracture or other injury	Interpret with age and overall case findings [22–27]
Cricoid/laryngeal structures	Fractures or soft-tissue injury	May occur in neck compression [22–25]
Other body regions	Abrasions, contusions, lacerations	May indicate associated trauma or restraint [19–21]

Table 5. Differential Diagnosis of Neck Compression Deaths

Condition	Principal mechanism	Typical investigative consideration	Important limitation
Hanging	Neck compression associated with suspension by ligature	Scene, ligature, suspension point and autopsy findings	No single finding is diagnostic [19,43]
Ligature strangulation	Ligature compression without suspension by body weight	Examine ligature mark, neck injuries and scene	Findings may overlap with hanging [19,21,31]
Manual strangulation	Compression by hands/fingers	Look for neck injuries and associated trauma	External findings can be variable [19,31]
Accidental neck compression	Unintentional compression	Detailed reconstruction of accident mechanism	Circumstances are critical [19,20]
Postmortem simulation/staging	Body suspended after death	Correlate scene and autopsy findings	Requires multidisciplinary assessment [19,20,32]

Table 6. Role of Toxicology in Hanging Investigations

Specimen / investigation	Potential information	Forensic relevance
Peripheral blood	Alcohol, drugs and toxic substances	Important for interpretation of circumstances [29,30]
Urine	Evidence of previous exposure/metabolites	Supportive toxicological information [29,30]
Vitreous humor	Selected biochemical/toxicological parameters	Useful in appropriate circumstances [29,30]
Gastric contents	Recently ingested substances	May assist interpretation of ingestion [29,30]
Liver/tissues	Selected drugs or toxic substances	Useful when indicated [29,30]
Alcohol analysis	Blood alcohol concentration	May influence behaviour and circumstances [29]
Drug screening	Prescription/recreational drugs	May affect consciousness, coordination and judgement [29,30]
Integrated interpretation	Correlation with scene and autopsy	Toxicology should not be interpreted in isolation [29,30,44]

Table 7. Modern Technologies Applicable to Forensic Hanging Investigations

Technology	Potential application	Current role
PMCT	Fractures, skeletal injuries, foreign material and anatomical findings	Complementary to conventional autopsy [36–38]
PMMRI	Soft-tissue and selected anatomical abnormalities	Complementary imaging modality [38]
3D reconstruction	Visualization of anatomical and traumatic findings	Useful for documentation and communication [39,42]
Digital photography	Standardized documentation of scene and injuries	Essential forensic documentation [40,41]
Macro photography	Detailed examination of ligature marks	Improves documentation of local morphology [40]
Digital scene reconstruction	Spatial reconstruction of hanging scene	Supports later review and interpretation [40,42]
AI-assisted image analysis	Automated or semi-automated assessment of forensic images	Emerging; requires validation [46–48]
Digital evidence analysis	Mobile, CCTV, communications and location information	Provides contextual/investigative information [33–35]
Advanced toxicology	Broader and more sensitive substance detection	Supports interpretation of circumstances [29,30]

Table 8. Common Interpretative Errors and Recommended Forensic Approaches

Common error	Why it is problematic	Recommended forensic approach
Assuming every hanging is suicidal	Scene alone does not establish manner	Integrate scene, autopsy and investigative evidence [19,20,43]
Relying exclusively on ligature mark	Morphology is variable and nonspecific	Correlate mark with ligature, scene and autopsy [16–18]
Considering hyoid fracture proof of homicide	Fractures occur in different circumstances	Interpret fracture with age, mechanism and complete findings [22–27]
Ignoring partial suspension	Fatal hanging can occur with incomplete suspension	Document degree of suspension carefully [1,2,43]

Inadequate scene documentation	May prevent reconstruction	Photograph and document before disturbing evidence [9,10,40]
Ignoring toxicology	Drugs/alcohol may influence circumstances	Perform appropriate toxicological examination [29,30]
Examining only the neck	Associated injuries may be missed	Conduct complete external and internal examination [19–23]
Treating PMCT as a replacement for autopsy	Some injuries may be missed or incompletely characterized	Use PMCT as a complementary modality [36–38]
Overinterpreting digital evidence	Digital information may lack context/authentication	Integrate authenticated digital evidence with physical findings [33–35]
Using emerging AI as an independent diagnosis	Validation and generalizability remain limitations	Use AI as an adjunct until adequately validated [46–48]