

St. Paul's Hospital Millennium Medical College



Department of Forensic Medicine and Toxicology

A comparative study of hanging and strangulation cases based on gross postmortem findings from April, 2021 to November, 2021 in Ethiopia - A cross-sectional study

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List of acronyms and abbreviations

AA	Addis Ababa
COD	Cause of Death
FMT	Forensic Medicine and Toxicology
IRB	Institutional Review Board
LM	Ligature mark
ML	Medicolegal
PME	Postmortem examination
PML	Postmortem lividity
SCM	Sternocleidomastoid
SPHMMC	Saint Paul's Hospital and Millennium Medical College
SPSS	Statistical Package for Social Science

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Abstract

Background: Hanging and strangulation are two forms of violent mechanical asphyxia due to constriction of the neck and, in practice, the distinction between the two group is very important because strangulation is usually homicidal and hanging in vast majority is considered to be suicidal. Thus, this study was planned to identify gross morphological features in cases of hanging and strangulation and use it, whenever complete information as to the circumstance of death is not provided.

Objective: To compare cases of hanging and strangulation, based on gross postmortem findings, presented for medicolegal autopsy to SPHMMC, A.A, Ethiopia.

Methods: A comparative, cross-sectional study was conducted from April 1, 2021 G.C. to November 30, 2021 G.C. in the department of FMT, SPHMMC, A.A, Ethiopia. All cases of hanging and strangulation presented to the mortuary of SPHMMC for medicolegal autopsy during the study period were included. Data was entered and analyzed using SPSS 24.

Results: During this period, a total of 2016 cases of medicolegal autopsy were conducted, out of which 94 (4.66%) cases were due to external compression of neck. Out of the 94, there were 83 (88%) hanging and 11 (12%) strangulation (45.5% ligature and 54.55 manual) cases; there was a male predominance with 67% males and 33% females with mean ($\pm$ SD) age of 34.27 ($\pm$ 14.3). In hanging cases, maximum number of cases were seen between 31-40 years with male predominance 69.9%.; The ligature marks were oblique in 100%, discontinuous in 63.4%, above thyroid cartilage in 85.5% with dry, pale and glistening undersurface in 98.8%. Injuries other than LM were seen in only few cases, external signs of asphyxia were absent in 43.4%, salivary stains in 8.4% and PML over the extremities in 20.5%. Contusion of neck muscles in 4.8% and fracture of hyoid bone and thyroid horn in 10.8% and 3.6% respectively. In strangulation cases, 21-30 years group were most vulnerable with slight female predominance (54.5%); the LMs were transverse in 60%, discontinuous in 60%, at the thyroid cartilage in 100% with contused undersurface in 40%. Injuries other than LM were common, at least 1 external sign of asphyxia was seen in all cases, salivary stains and PML over the extremities in 0%. Contusions of neck muscles were common (72.7%) and fracture of hyoid bone and thyroid horn being 36.4% each.

Conclusion and recommendation: Oblique LM, presence of LM above the thyroid cartilage, undersurface of LM being dry, pale and glistening, absence of external signs of asphyxia, presence of dried salivary stains and absence of contusion of underlying neck muscles are suggestive of hanging while transverse LM, presence of LM at the level of thyroid cartilage, contused undersurface of LM and presence of contusions of underlying neck muscles especially the deep ones are suggestive of strangulation.

Key words: Medicolegal autopsy, hanging, strangulation, postmortem findings, ligature mark, Ethiopia

1. Introduction

1.1 Background

Asphyxia is a term derived from Greek that literally translates as "stopping of the pulse." Asphyxial deaths are potentially associated with a large number of physical findings, reflecting the broad scope of the causes of asphyxia. The causes of asphyxia can be broadly categorized as mechanical or chemical. Chemical asphyxia usually involves a reaction between a chemical and the body, primarily resulting in interference with oxygen uptake, transport and/or utilization. Mechanical asphyxia usually involves some physical force or abnormality affecting breathing or circulation. ^[1,2]

Death due to asphyxia may be natural, or unnatural (homicidal, suicidal or accidental in nature). Asphyxial deaths are one of the most common homicidal and suicidal deaths. There are findings that are typical of asphyxia such as petechial hemorrhages, congestion, cyanosis, pulmonary edema and enlargement of the right side of the heart; however, these are nonspecific and can be found in other types of deaths. Some deaths due to asphyxia will have none of the characteristic findings. ^[2]

Mechanical asphyxia is most commonly encountered type in medico legal practice. Different types of mechanical/violent asphyxial deaths include hanging, strangulation, drowning and suffocations. Among the means of producing mechanical asphyxia, constriction around the neck (hanging and strangulation) plays a major role and among them, hanging is the commonly used method of committing suicide while strangulation is the commonly used method for homicidal purpose. ^[1,2]

Hanging, a form of violent asphyxia, is due to constriction of neck as a result of suspension of the body in such a manner that the weight of the body or a part of the victim's body weight pulls upon the ligature. Hanging is one of the most common methods of suicide; other types of hangings are homicidal hanging, judicial hanging, and autoerotic hanging. ^[3]

Strangulation, also a form of violent asphyxia, is caused by constriction of the neck by means of a ligature material or by some other means, without suspending the body of the victim, where the force of constriction is applied from outside (exogenous in origin) and is not the weight of the body or the head of the victim. Various forms of strangulations are ligature strangulation, manual strangulation, mugging, garroting, bansdola, etc. In strangulation by ligature, the ligature material is tightly tied around the neck. The factor of suspension differentiates hanging from strangulation by ligature; the latter being caused by application of a ligature of the neck in such a way that the force acting upon it is other than the weight of the body. ^[1,4]

Apart from direct neck constriction, additional asphyxiating factor found in cases of hanging and strangulation is obstruction of the laryngeal inlet by upward displacement of the tongue and pharynx resulting in the floor of the mouth being jammed against its roof and occluding the air passage. The autopsy diagnosis of death due to fatal compression of neck is extremely difficult and sometimes goes unnoticed if the ligature mark is faint or invisible. ^[4]

Despite the availability of extensive studies on the topic in other regions of the world and even in the African continent such a study is lacking in Ethiopia as our country has neither national nor regional data on autopsy findings of fatal pressures on the neck caused by hanging and strangulation. Hence, this study aims to correlate the neck markings together with the internal

findings as they are extremely important in arriving at a conclusion and compare it with the pattern seen in other parts of the world.

1.2 Statement of the problem

Deaths due to compression of neck are one of the most important unnatural deaths encountered by forensic experts. Findings resulting from application of pressure on the neck quite vary. Thus, a forensic pathologist is caught in a dilemma when there are atypical findings in addition to the typical ligature mark. ^[5]

It has been shown that deaths due to hanging are common among the suicides in many countries around the world. The characteristic finding, the ligature mark, found around the neck in both hanging and strangulation creates an element of doubt in many cases. The difficulty increases many folds when one has to differentiate ligature mark of homicidal hanging from strangulation, as associated bodily injuries will be found on both occasions, though in partial hanging it may not be difficult due to absence of marks of violence and resistance. ^[6,7]

Even when the body is found suspended the forensic expert has to give an opinion on the manner of death and to exclude or confirm other forms of neck compression prior to being hung. In the case of a typical suspension the mark will rise to an inverted “V” shape with a gap at the back of the neck. This is often used to distinguish a hanging from a ligature strangulation. However, in a hanging from a low suspension point, the marks on the neck tend to be horizontal rather than diagonal simulating ligature strangulation. ^[5]

The department of forensic medicine and toxicology in Saint Paul’s hospital and millennium medical college which was established early in the past decade has been working with the justice system in by providing evidence-based results from conducting postmortem

examinations on thousands of dead bodies brought to the center from every corner of the country each year. The department had received more than 6800 dead bodies to be autopsied in 2018 and nearly 5000 dead bodies to be autopsied in 2019.

From the 4918 dead bodies brought for autopsy in 2019, about 400 were hanging cases and about 25 were cases of strangulation. Although the number of strangulation cases are limited when compared to the staggering number of hanging cases sometimes differentiating between the two gets tricky and a proper assessment of various post-mortem findings is therefore necessary to arrive at a conclusion.

The present study is planned to establish reliable gross morphological features for differentiating asphyxial deaths due to compression of neck in hanging and strangulation.

1.3 Significance of the study

In practice, the distinction between the two groups is very important because strangulation is usually homicidal and hanging in vast majority is considered to be suicidal. So, many times there are so many difficulties in diagnosing hanging and strangulation faced on many occasions.^[6,7] The pattern of external and internal injuries and other postmortem findings resulting from neck compression permit a forensic pathologist to resolve many unanswered questions.

Like all other cases, the determination of cause of death in fatal pressures over the neck has to be based on history, death-scene investigation and a thorough postmortem examination including all the necessary ancillary investigative modalities but here we are missing one of the main elements which is death-scene investigation. Because of the presence of handful forensic experts in the country and lack of a system for corroboration with the police,

death/crime scene visits could not be carried out by the few forensic experts residing in A.A. Hence, we might have to depend on postmortem findings to reach at a conclusion. Thus, a comparative study of gross postmortem findings in cases of hanging and strangulation will be carried out in the department of FMT, SPHMMC, A.A, Ethiopia.

Role of this study is mainly that it will produce a scientific corroboration of circumstantial evidence and gross postmortem findings in asphyxial deaths caused by constriction of the neck in hanging and strangulation.

2. Literature review

Hanging differs from strangulation in which the neck is constricted irrespective of any effect caused by the weight of the body. The various structures damaged in hanging and strangulation include the soft tissues like skin, subcutaneous tissue, fascia, muscles, blood vessels and the bony/cartilaginous tissues like the hyoid bone and laryngeal structures. [8]

There are multiple factors that are used for differentiating hanging from strangulation such as the ligature mark, signs of asphyxia, injuries to the internal neck structures and associated bodily injuries.

Ligature mark

The ligature mark is a vital piece of evidence in asphyxial deaths especially when the killer has taken away the actual ligature. Ligature mark is found as pressure mark on the neck underneath the ligature. Initially it appears as a pale groove which on drying becomes reddish brown parchment like. Taking the most important finding i.e., ligature mark into consideration, there are a few points like (1) level (2) discontinuity (3) obliquity of the ligature mark which differentiate hanging from ligature strangulation. However, it is a fact that not all these differentiating features are present simultaneously in all cases of hangings and strangulations. [3,7]

In a study done in Gujarat, India on death due to compression of neck by ligature in the department of forensic medicine, Shri M P Shah Govt. Medical College, Jamnagar which included 100 cases over a period of 2 years of which 97 were hanging and 3 were strangulation. Out of 97 cases of hanging the ligature mark color were pale in 29 cases (29.9%) and reddish

brown in 68 cases (70%). In 3 cases of ligature strangulation pale color in 1 case and reddish brown in 2 cases. Out of 97 cases of hanging complete ligature mark seen in 19 cases whereas incomplete ligature mark in 78 cases. Out of 3 cases of ligature strangulation, complete ligature mark seen in 2 cases and 1 case shows incomplete ligature mark. Out of 100 cases in 95 cases ligature mark was oblique in direction, 93 were of hanging and 2 were of ligature strangulation. In rest of 5 cases the ligature mark was transverse in direction, 4 were of hanging and 1 was of ligature strangulation. In 97 cases of hanging, it was found 1 ligature mark in 90 (92.78%) cases of followed by 2 marks in 6 (6.18%) cases and >3 mark in 1 (1.03%) case. Out of 3 cases of ligature strangulation 2 mark seen in 2 (66.66%) cases and >3 mark in 1(33.33%) case. The ligature mark situated above thyroid cartilage in 64 (65.97%) cases, over thyroid cartilage in 30 (30.92%) cases and below thyroid cartilage in 3 (3.09%) cases. Out of 3 cases of ligature strangulation, the ligature mark was situated on thyroid cartilage in 3 (100%) cases. ^[9]

In another study done in Jharkland, India on comparison of ligature marks in cases of hanging and strangulation in the department of FMT, Rajendra Institute of Medical Sciences (RIMS), Ranchi over a period of 1 year which included 180 cases with ligature marks. There were 163 cases of hanging (5.47% of total 2981 cases) and 17 cases of strangulation (0.57% of total 2981 cases). Out of 180 cases, 90.56% (163) were of hanging and 9.44% (17) were of strangulation. The ligature mark in hanging was oblique in 100% cases, discontinuous in 96.93% cases and the subcutaneous tissue underneath the ligature mark was pale and dry in 100% cases. The ligature mark in strangulation was transverse in 100% cases, continuous in 100% cases and subcutaneous tissue underneath the mark was contused in 88.2% cases. It was concluded that oblique and discontinuous ligature mark along with dry and pale subcutaneous tissue is

suggestive of hanging while a transverse and continuous ligature mark with contused subcutaneous tissue is indicative of strangulation. ^[10]

Signs of asphyxia

For many years the autopsy diagnosis of an asphyxial death was made by reference to a set of findings that have come to be known as the ‘classic signs of asphyxia’. Unfortunately, it is now quite clear that most of these signs are so non-specific that little reliance can be placed on them in the absence of other confirmatory evidence. It cannot be emphasized too strongly that the mere finding of any of the non-specific features, such as petechiae, congestion and cyanosis, without firm circumstantial or preferably physical evidence of mechanical obstruction of respiration, is quite insufficient to warrant a speculative diagnosis of asphyxia. Most important of all is the finding of a cause for airway obstruction or other local trauma, such as prolonged pressure on the neck. ^[6]

In a study done in Gujarat, India on death due to compression of neck by ligature in the department of forensic medicine, Shri M P Shah Govt. Medical College, Jamnagar which included 100 cases over a period of 2 years of which 97 were hanging and 3 were strangulation. Facial features were pale in 59 (60.83%) cases of hanging and 2 (66.66%) cases of ligature strangulation. It was found congested in 38 (39.17%) cases of hanging and 1 (33.33%) cases of ligature strangulation. Cyanosis in nail beds was seen in 66 cases of hanging and 2 case of ligature strangulation. Out of total 97 cases of hanging, dribbling of saliva was found in 28.86% cases and dribbling of saliva was not found in any cases of ligature strangulation. ^[9]

In another study done in New Delhi, India on postmortem findings of neck structures in cases of asphyxial deaths in the department of forensic medicine, Maulana Azad Medical College,

New Delhi which included 73 cases of asphyxial deaths over a period of 1 and half year of which 58 cases were due to constriction of the neck (52 cases of hanging, 5 cases of manual strangulation and 1 case of ligature strangulation). In this study, facial congestion and saliva stain were present in <50% of cases and petechial hemorrhages in 58.62% of cases of which 61.53% of cases were of hanging, and 33.33% of cases were of strangulation. ^[11]

In a similar study done in Shanghai, China to explore the characteristics of hanging and strangulation in cases done by Shanghai Municipal Public Security Bureau over a period of 4 years which included 319 cases of which 141 were cases of hanging and 178 were cases of strangulation. In hanging cases, the most common asphyxia-related phenomenon was hemorrhagic spots on bulbar conjunctiva and palpebral conjunctiva (65.96%), followed by cyanosis on the lips and fingernails (65.25%). In strangulation cases, the commonest asphyxia phenomenon is hemorrhagic spot of bulbar conjunctiva and palpebral conjunctiva (89.02%), followed by hemorrhage spot (57.23%) and cyanosis (53.76%) on the face. The commonest asphyxia phenomenon inside the body in both the hanging and strangulation cases was hemorrhagic spot on the epicardium and lung. Dark-red heart blood, hemorrhage of the epiglottis, and congestion in organ parenchyma were also very common in these cases. Other asphyxia phenomena such as the hemorrhage of gingiva and root of tongue were more common in the strangulation cases than in the hanging cases. ^[12]

Injuries to the muscles of the neck

In cases of strangulation, internally, contusions may be visible to a greater or lesser extent in the tissues of the neck. Often, they are quite superficial and are confined to the dermis, but some may be visible to an appreciable depth in the muscles and other structures in the neck. The platysma muscle may be bruised, but the sternomastoid and the deeper strap muscles that

run vertically along the larynx may show patchy bleeding, not always corresponding exactly to the position of surface bruises. On the contrary, in cases of hanging, in the neck tissues there may be surprisingly little to find with an absence of strap muscle hemorrhage being a common finding. However, the literature suggests that an average figure for the incidence of soft tissue hemorrhage would be about 20–30 per cent of cases. Occasionally, muscle fibres of platysma and sternomastoid may get ruptured, especially in long drops or complete hangings. ^[6]

In a study done in Shanghai, China to explore the characteristics of hanging and strangulation in cases done by Shanghai Municipal Public Security Bureau over a period of 4 years which included 319 cases of which 141 were cases of hanging and 178 were cases of strangulation. Neck muscle hemorrhage was revealed in 22 (47.83%) autopsies of hanging cases and 134 (80.72%) autopsies of strangulation cases. In this study, the sternocleidomastoid was found to be the commonest hemorrhagic muscle in hanging cases. However, the deeper muscles of the sternohyoid and sternothyroid are the commonest hemorrhagic muscles involved in strangulation cases. This is because the direction of force is often perpendicular to the dorsal plane, and the position of the acting force is often lower in such cases. ^[12]

In another study done in India, in asphyxial deaths due to external compression of the neck in the department of FMT, at mortuary of SRN Hospital, MLN Medical College, Allahabad, and Uttar Pradesh which included 82 cases of external compression of neck over a period of 1 year of which 69 were hanging and 13 were strangulation (9 manual and 4 ligature). In the study, the underlying muscles showed bruising and hemorrhage in 40.75% of observed hanging cases, 50% cases of observed ligature strangulation and 66.66% in throttling cases. The study observed injury to sternocleidomastoid muscle in 54% of cases of deaths due to external compression of neck. ^[14]

Fracture of neck structures

Osteocartilagenous structures of neck like hyoid bone, thyroid cartilage, tracheal cartilages and cervical vertebrae show injury with variable incidences in cases of hanging and ligature strangulation.

Hyoid bone is commonest to be injured in conventional hanging cases, whereas fracture or dislocation of cervical vertebrae may be noticed in judicial hanging where the victim jumps from a height and his fall is arrested by a sudden jerk of ligature. The fracture of hyoid bone depends on age of individual and type of compression. After the ossification of greater cornu with body after 40 years there is loss of mobility and in turn variation in incidence of fracture of hyoid bone in case of hanging has been reported by different experts. The type of hyoid bone fracture (if present) can help to decide the manner of neck compression hanging or strangulation (ligature or manual). Commonly, the lateral compression fracture is seen in strangulation and anteroposterior fracture of hyoid bone suggests hanging. However, whether each fractured piece displaced inward or outward and opinion about type of neck compression needs careful observation and expert interpretation. ^[7]

In a study done in Gujarat, India on death due to compression of neck by ligature in the department of forensic medicine, Shri M P Shah Govt. Medical College, Jamnagar which included 100 cases over a period of 2 years of which 97 were hanging and 3 were strangulation. Out of these 100 cases of compression of neck by ligature, injury to hyoid bone in 2 cases and thyroid cartilage in 1 case was observed. Fracture of cricoid cartilage, tracheal rings and cervical vertebrae were not observed in any cases of neck compression which was in contrast to observation of other workers. Out of these 2 cases of hyoid bone fracture one (33.33%) case was of ligature strangulation of adult female and one (1.03%) case was of hanging of elderly

male victim. Thyroid cartilage fracture was seen in one (33.33%) case of ligature strangulation of young female. ^[9]

In another study done in India, on asphyxial deaths due to pressure over the neck with special reference to hyoid bone fracture in the department of FMT, Surat Municipal Institute of Medical Education and Research, Surat, Gujarat, India which included 100 cases of fatal neck compression over a period of 1 year of which 95 were hanging and 5 were ligature strangulation. Out of the 100 cases studied, hyoid bone fracture was found in 16 cases (13 cases were male and 3 cases were female) and thyroid cartilage fracture was found in 4 cases (3 cases were male and 1 case were female), in 1 case both hyoid & thyroid were fractured and rest of the cases does not show any fracture. In 4 cases fracture of hyoid bone was due to strangulation (2 males and 2 females). The other neck structures like cricoid cartilage and cervical spine did not show any fracture. ^[13]

In a similar study done in New Delhi, India on postmortem findings of neck structures in cases of asphyxial deaths in the department of forensic medicine, Maulana Azad Medical College, New Delhi which included 73 cases of asphyxial deaths over a period of 1 and half year of which 58 cases were due to constriction of the neck (52 cases of hanging, 5 cases of manual strangulation and 1 case of ligature strangulation). In this study, the incidence of fracture of hyoid bone was common and seen in 8.62% followed by fracture of thyroid cartilage (6.89%) and intimal tears found in 5.17% of cases. Fracture of cricoid cartilage not seen in even a single case. Hyoid bone fracture was more common in males (3 cases) as compared to females (2 cases) while thyroid cartilage fracture was more common in females. The occurrence of fracture of both bones simultaneously was equal in both sexes. Hyoid bone fracture was found in all the cases of LS, in 60% of cases of MS, and in 1.92% of cases of hanging. Fracture of

the left greater horn was more common (69% cases) followed by combined fractures of both greater cornu (66.66% cases) and followed by the right greater cornu (1.92%).^[11]

3. Objectives

3.1 General objective

- To compare hanging and strangulation cases, based on gross postmortem findings, presented for medicolegal autopsy to SPHMMC, A.A, Ethiopia during the study period

3.2 Specific objectives

- To assess the socio-demographic profiles of fatalities from hanging and strangulation
- To describe the pattern of ligature marks in asphyxial deaths due to compression of the neck by hanging and strangulation
- To assess associated body injuries other than to neck structures in cases of hanging and strangulation

4. Methods and materials

4.1 Study design, study period and study area

A comparative, cross-sectional study design was used and the study was conducted in the department of forensic medicine and toxicology, SPHMMC, Addis Ababa, Ethiopia over a period of 8 months from April 1, 2021 to November 30, 2021.

Description of the study area

Ethiopia, officially the Federal Democratic Republic of Ethiopia, is a landlocked country in East Africa. It shares borders with Eritrea to the north, Djibouti to the northeast, Somalia to the east, Kenya to the south, South Sudan to the west and Sudan to the northwest. With over 109 million inhabitants as of 2019, Ethiopia is the 12th most populous country in the world and the second most populous nation on the African continent (after Nigeria).

Its capital and largest city is Addis Ababa, which lies several kilometers west of the East African Rift valley with an estimated population of 7.1 million people in 2019 and located on 9°1'48"N 38°44'24"E coordinates.

Located in the capital city is the Saint Paul's Hospital and Millennium Medical college which is a tertiary referral and teaching hospital directly under the ministry of health. The hospital gives service to an average of 300,000 people annually with a catchment population of more than 5 million. There are over 13 department which include FMT and the hospital gives service under different clinical disciplines which include postmortem examination conducting about 5000 autopsies per year.

4.2 Target or reference population

Target population includes all alleged cases of hanging and strangulation brought for conduction of medicolegal autopsy to the department of FMT, SPHMMC in Addis Ababa,

Ethiopia during the period of the study. Since cases come for ML autopsy from every part of the country, the study can be fairly generalized to similar cases presented to the mortuaries of Menelik II hospital in A.A and Ayder hospital in Mekele, Tigray region, Ethiopia.

4.3 Study population

A comparative, cross-sectional study was conducted on all cases of hanging and strangulation brought for medicolegal autopsy to the department of FMT, SPHMMC in Addis Ababa, Ethiopia during the data collection period from April 1, 2021 to November 30, 2021.

4.4 Eligibility criteria

Inclusion criteria

- All cases of hanging and strangulation received for the performance of ML autopsy.

Exclusion criteria

- Highly decomposed or skeletonized bodies and charred burnt bodies.

4.5 Sampling technique and sample size

A non-probability convenience sampling was used and the study was inclusive of all hanging and strangulation cases received during the study period.

4.6 Study instrument

For data collection on comparative study of cases of hanging and strangulation, well-structured, self-filled predesigned and pretested proforma was developed depending on standard book sample formats and other similar studies with some modifications which comprised relevant data in order to attain the objective of this study.

4.7 Study variables

Dependent variables

- Postmortem findings (signs of asphyxia, ligature mark, injuries to neck structures)

Independent variables

- Socio-demographic variables (age and sex)
- Ligature materials
- Place and position of the body
- Associated injuries

4.8 Operational definitions

Autopsy: [syn; necropsy, post mortem examination, section cadaveris, thanatopsy] is the examination of a person's body after his death. It is an essential part of death investigation. An autopsy is of the two types – medicolegal autopsy and hospital autopsy. ^[7]

- **Medicolegal autopsy:** Done when some legal issue is involved (homicide, accident, suicide, any other suspicious death). Here a ML autopsy is carried out on the request of the investigating officer. Permission of relatives not required.
- **Hospital autopsy:** Done for academic purposes, research etc. No legal issue is involved (also called clinical autopsy or pathological autopsy). Permission of relatives required.

4.9 Autopsy methods

Detailed and complete external examination of the body was carried out along with dimensions of ligature mark, neck circumference and site of ligature mark, its pattern and

other gross morphological features. Routine instruments and materials of dissection were used for internal examination of the body. The neck structures were dissected to study the pathology caused by compression underneath the ligature mark.

Bloodless dissection of the neck was carried out by removing thoracoabdominal and cranial contents. Neck dissection was done in layers i.e., skin and subcutaneous tissue, muscles of neck, thyrohyoid complex, trachea and larynx. Any injury to the muscles of the neck and any fracture of the thyrohyoid complex were noted after removing the throat skeleton as a single mass.

4.10 Data collecting methods

Information regarding the bio data of the deceased and various factors related to the circumstances of death was gathered primarily from the police, police records, hospital records, death certificates and also by interviewing the investigating officer along with the eye witnesses, relatives and friends of the deceased aiding the investigating officers in providing a complete information.

The data were gathered by myself and other residents who work in the department of FMT through a series of interviews and questionnaires throughout the study period. A detailed proforma for recording the details of hanging and strangulation cases was prepared for filling the findings of this study. The data thus collected, was statistically analyzed as described down below.

4.11 Data processing and quality

Data entry was done by using Statistical Package for Social Sciences (SPSS) version 24. Data were cleaned with consistence checks and analyzed using the same SPSS package. Any errors identified at that time were corrected after revision of the original data using

the code numbers. To keep the quality of data the predesigned semi structured proforma was pretested. I checked every completed questionnaire. Anything, which is unclear and ambiguous, was discussed therein. About 10% of the data was double entered by the principal investigator to check consistency in putting data to SPSS. The data analysis using the same SPSS package was carried out after appropriate data entry task is be completed.

4.12 Data analysis

Data analysis was done using SPSS version 24. The descriptive analysis such as proportions, percentages, measures of central tendency and measure of dispersion were done. Finally, the findings were presented by using tables and figures as appropriate.

4.13 Ethical consideration

The study was started after approval from Saint Paul's hospital and Millennium Medical College Institutional Review board (IRB). Information used in this study was anonymized. PME numbers were assigned to individual cases, and the information were kept confidential from other parties excepting the investigating authorities. The study involved ML cases brought to the mortuary by the police and not the relatives of the deceased. The information was taken primarily from the police allowing the relatives to be present during history taking only to help the police. The information gained from the history and postmortem examination were included in the post mortem report to help in the investigation by the police whether the relatives agree or not. The identification details of the deceased were not be revealed at any stage.

4.14 Dissemination of results

The result will be presented as part of final year dissertation paper for SPHMMC's post graduate committee. Additionally, the study result will be disseminated to forensic experts

who serve in the other two mortuaries which carry out ML autopsies and academic partners working on this area, further attempt will be made to publish it on national and international scientific journals.

5. Results

A total of 2016 medicolegal autopsies were conducted at the mortuary of department of FMT, SPHMMC, during the study period from April 1, 2021 G.C. to November 30, 2021 G.C. Out of the 2016 autopsied cases, it was determined that in 94 cases (4.66%) the cause of death was due to fatal pressures over the neck (83 cases were of hanging and 11 cases were of strangulation (5 were of ligature strangulation and 6 were of manual strangulation)).

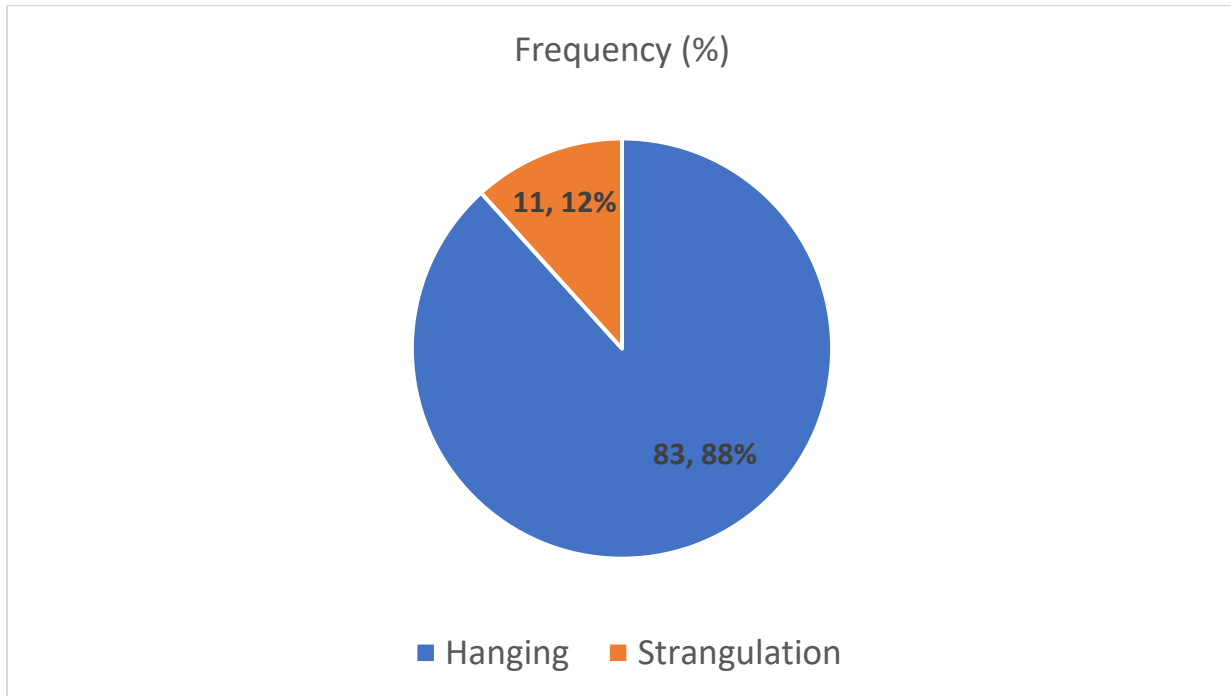


Figure 1: Pie chart, Cause of death, based distribution of cases (n=94)

Sex and age distribution of cases

Sex distribution of all victims of fatal pressure over the neck (both hanging and strangulation) shows a male predominance with 63 (67%) males and 31 (33%) females.

As shown in table 1, out of 83 victims of hanging, 58 (69.9%) were males and 25 (30.1%) were females as compared to, out of 11 victims of strangulation, 5 (45.5%) were males and 6 (54.5%) were females. The male to female ratio was 2.32:1 and 1:1.2 for victims of hanging and strangulation respectively.

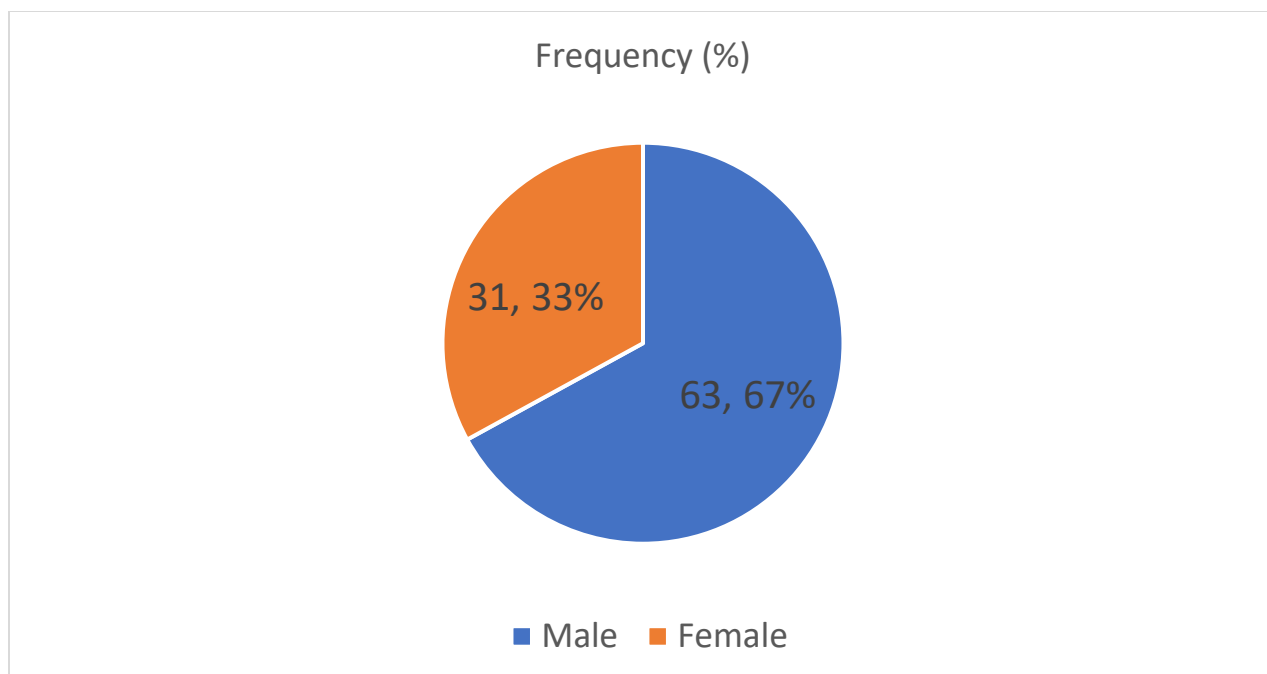


Figure 2: Pie chart, Overall sex distribution (n=94)

Table 1: Sex and Cause of death cross tabulation (n=94)

			Sex		Total
			Female	Male	
Cause of death	Hanging	Count	25	58	83
		% within Cause of death	30.1%	69.9%	100.0%
	Strangulation	Count	6	5	11
		% within Cause of death	54.5%	45.5%	100.0%
Total		Count	31	63	94
		% within Cause of death	33.0%	67.0%	100.0%

The most frequently involved age groups in cases of hanging were the 31-40 years old age group, with 29 (34.9%) cases closely followed the 21-30 years old age group, with 27 (32.5%) cases, and the least involved age group being the less than 10 years old ones; however, the most frequently involved age groups in cases of strangulation were the 21-30 years old age group, with 3 (27.3%) cases and the least involved age group being the under 10 years old and 41-50 years old age groups with 1 (9.1%) case each.

Table 2: Age category and cause of death cross tabulation (n=94)

			age group						Total
			under 10	11-20	21-30	31-40	41-50	51 and older	
Cause of death	Hanging	Count	1	9	27	29	6	11	83
		% within Cause of death	1.2%	10.8%	32.5%	34.9%	7.2%	13.3%	100.0%
	Strangulation	Count	1	2	3	2	1	2	11
		% within Cause of death	9.1%	18.2%	27.3%	18.2%	9.1%	18.2%	100.0%
Total	Count	2	11	30	31	7	13	94	
	% within Cause of death	2.1%	11.7%	31.9%	33.0%	7.4%	13.8%	100.0%	

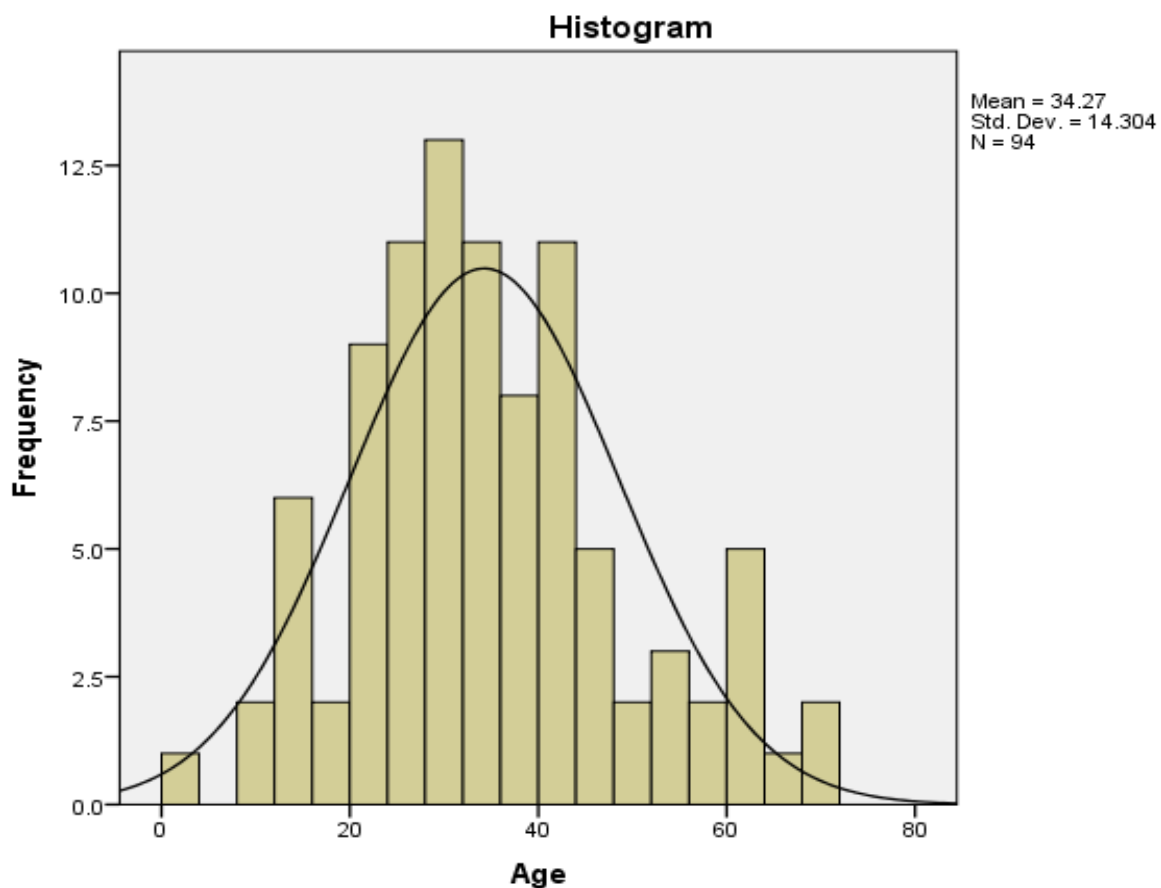


Figure 3: Histogram, Distribution of cases based on age (n=94)

Table 3: Age distribution of cases (n=94)

Cause of death	Mean	N	Std. Dev.
Hanging	34.64	83	13.699
Strangulation	31.46	11	18.815
Total	34.27	94	14.304

Ligature mark

Out of the total 94 cases, ligature marks were present in 88 (93.6%) of the cases; LMs were present in all 83 (100%) cases of hanging but present only in 5 (45.5%) cases of strangulation, constituting ligature strangulation. In 85 (96.6%) of the cases with LM, the mark was 1 in number and 2 in the rest 3 (3.4%) cases, and all the 3 cases were of hanging.

It was found that, ligature marks in all 83 (100%) of hanging cases were oblique and ligature marks in ligature strangulations were transverse/horizontal in 3 (60%) and oblique in 2 (40%) of the cases.

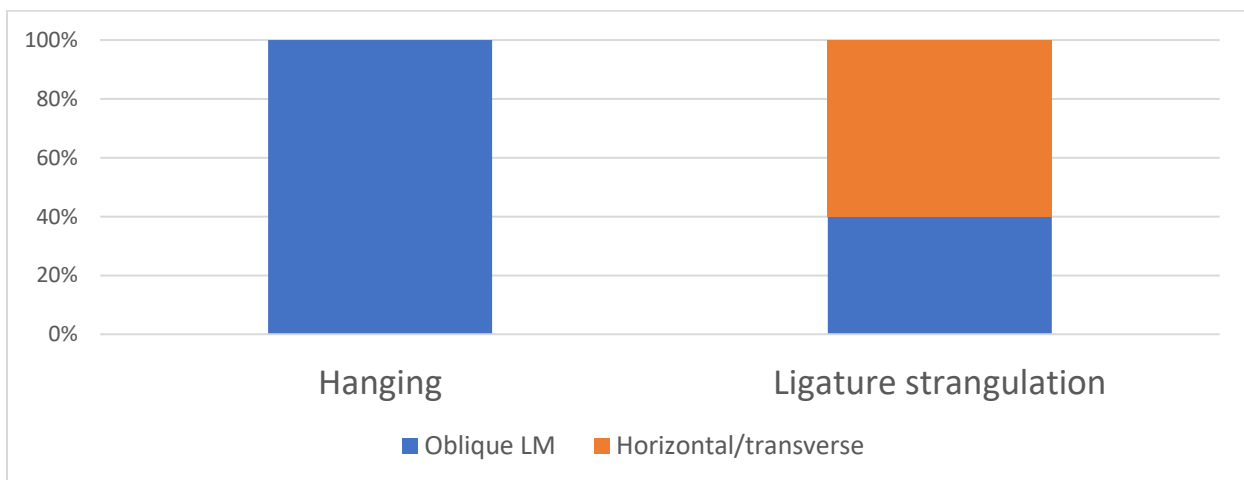


Figure 4: Stacked column, Cause of death and orientation of ligature mark (n=88)

It was found that, out of the 83 hanging cases, 53 (63.4%) of the ligature marks were discontinuous and 30 (36.6%) were continuous as compared to the 3 (60%) discontinuous and 2 (40%) continuous ligature marks seen in ligature strangulation.

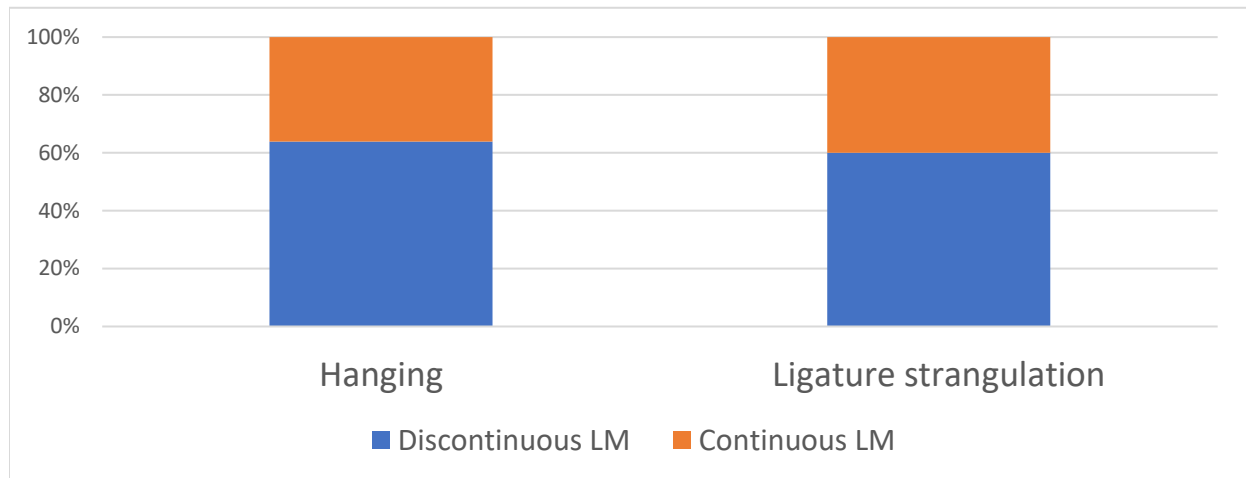


Figure 5: Stacked column, Cause of death and continuity of ligature mark (n=88)

As shown in table 4, ligature mark in victims of hanging was situated above the thyroid cartilage in 71 (85.5%), at the level of thyroid cartilage in 10 (12%) and below the thyroid cartilage in 2 (2.4%) of the cases as compared to ligature mark in victims of ligature strangulation which was situated at the level thyroid cartilage in all 5 (100%) of the cases.

Table 4: Cause of death and level of ligature mark cross tabulation (n=88)

			Level of LM			Total
			Above thyroid cartilage	At thyroid cartilage	Below thyroid cartilage	
Cause of death	Hanging	Count	71	10	2	83
		% within Cause of death	85.5%	12.0%	2.4%	100.0%
	Strangulation	Count	0	5	0	5
		% within Cause of death	0.0%	100%	0.0%	100.0%
Total		Count	71	15	2	88
		% within Cause of death	80.6%	17.0%	2.2%	100.0%

Although ligature mark was found in 88 (93.6%) of the cases, ligature material was furnished along with the bodies of the victims in only 39 (44.3%) cases, of which, 36 of the ligature materials were brought along with victims of hanging and the rest 3 ligature materials with ligature strangled victims; Out of those, the most common type of ligature material was narrow and hard type (n=28) of which nylon rope (n=16) was the most frequently used ligature material in hanging and piece of cloth (scarf and towel) was used to strangle victims.

Out of the 39 ligature materials brought along with the body, the most frequently observed type of knot was sliding knot in 28 (71.8%) cases, followed by fixed knot in 9 (23%) and in two case the ligature material was not knotted. From the 36 hanging cases with ligature materials, 27 (75%) had sliding knot and 9 (25%) had fixed knot as compared to the 3 cases of ligature strangulation with ligature materials where 1 (33.3%) had sliding knot and 2 (66.7%) case not knotted.

Table 5: Cause of death and type of ligature material cross tabulation (n=88)

			Type of ligature material				Total
			Broad and hard	Broad and soft	Narrow and hard	Ligature material NA	
Cause of death	Hanging	Count	2	7	27	47	83
		% within Cause of death	2.4%	8.4%	32.5%	56.6%	100.0%
	Ligature strangulation	Count	0	2	1	2	5
		% within Cause of death	0.0%	40%	20%	40%	100.0%
Total		Count	2	9	28	49	88
		% within Cause of death	2.2%	10.2%	31.8%	55.7%	100.0%

N.B. In this study, the hard and narrow ligature materials seen include nylon rope, fiber rope, electric wires and hard plastic materials; Soft and broad ligatures include shirt, towel, scarf, linen and other pieces of cloth and hard and broad ligatures include belt and flat plastic materials used.

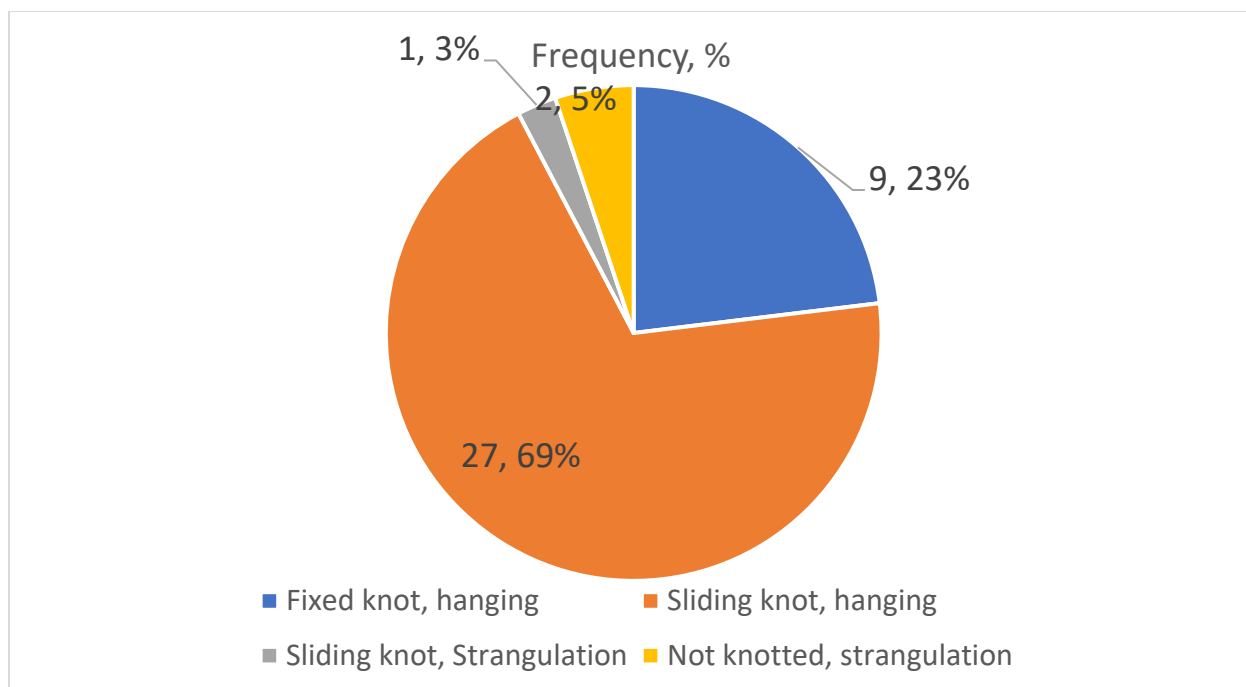


Figure 6: Pie chart, Cause of death and type of knot used (n=39)

As shown in table 6, color of ligature mark was reddish to dark brown in almost all cases of hanging (n=82, 98.8%) as compared to reddish to dark brown in 3 (60%) cases and pale in 2 (40%) of ligature strangulation.

And as shown in table 7, the undersurface of the ligature mark appeared dry, pale and glistening in almost all cases of hanging (n=81, 97.6%) and 2 (2.4%) cases with contused undersurfaces as compared to 2 (40%) cases with contused undersurfaces in ligature strangulation.

Table 6: Cause of death and color of ligature mark cross tabulation (n=88)

			Color of LM		Total
			Pale	Reddish to dark brown	
Cause of death	Hanging	Count	1	82	83
		% within Cause of death	1.2%	98.8%	100.0%
	Ligature strangulation	Count	2	3	5
		% within Cause of death	40%	60%	100.0%
Total		Count	3	85	88
		% within Cause of death	3.4%	96.6%	100.0%

Table 7: Cause of death and ligature mark undersurface cross tabulation (n=88)

			Ligature mark under-surface			Total
			Contused	Pale	Dry, pale and glistening	
Cause of death	Hanging	Count	2	0	81	83
		% within Cause of death	2.4%	0.0%	97.6%	100.0%
	Ligature strangulation	Count	2	3	0	5
		% within Cause of death	40%	60%	0%	100.0%
Total		Count	4	3	81	88
		% within Cause of death	4.5%	3.4%	92%	100.0%

Other neck and bodily injuries on external examination

As shown in table 8, different external neck injuries other than ligature mark were seen in 3 (3.6%) of hanging cases as compared to 6 (63.6%) of strangulation cases. Other associated external bodily injuries were found in 11 (13.3%) of hanging cases and in 9 (81.8%) of strangulation cases.

Table 8: Cause of death and other external neck injuries cross tabulation (n=94)

			Other neck injuries				Total
			Nail marks	Abrasions	Absent	Contusion	
Cause of death	Hanging	Count	0	3	80	0	83
		% within Cause of death	0.0%	3.6%	96.4%	0.0%	100.0%
	Strangulation	Count	1	5	4	1	11
		% within Cause of death	9.1%	45.5%	36.4%	9.1%	100.0%
Total		Count	1	8	84	1	94
		% within Cause of death	1.1%	8.5%	89.4%	1.1%	100.0%

NB. The abrasions seen over the neck include single to multiple small abrasions of different shapes including linear abrasions.

Table 9: Cause of death and other bodily injuries (n=94)

			Other bodily injuries		Total
			Absent	Present	
Cause of death	Hanging	Count	72	11	83
		% within Cause of death	86.7%	13.3%	100.0%
	Strangulation	Count	2	9	11
		% within Cause of death	18.2%	81.8%	100.0%
Total		Count	74	20	94
		% within Cause of death	78.7%	21.3%	100.0%

N.B. The other bodily injuries seen include simple abrasions and contusion at different sites of the body to significant contusions of the scalp and chop injury to the neck; the more significant injuries were associated with victims who were strangled to death.

Unrelated gross pathology was found in only one hanging case (Left ventricular hypertrophy).

Signs of asphyxia

Among the external signs of asphyxia found during examination, in hanging cases, the most common feature was facial congestion constituting 12 (14.5%) cases, closely followed by conjunctival congestion and cyanosis of the lips and tongue, each constituting 10 (12%) cases. Similarly, in strangulation cases, the most common features were facial and conjunctival congestions each constituting 4 (36.4%) cases, followed subconjunctival hemorrhages which were seen in 2 (18.2%) of the cases.

In hanging cases, all external signs of asphyxia were absent in 36 (43.4%) of the cases while in cases of strangulation at least one sign of external asphyxia was recorded in all cases.

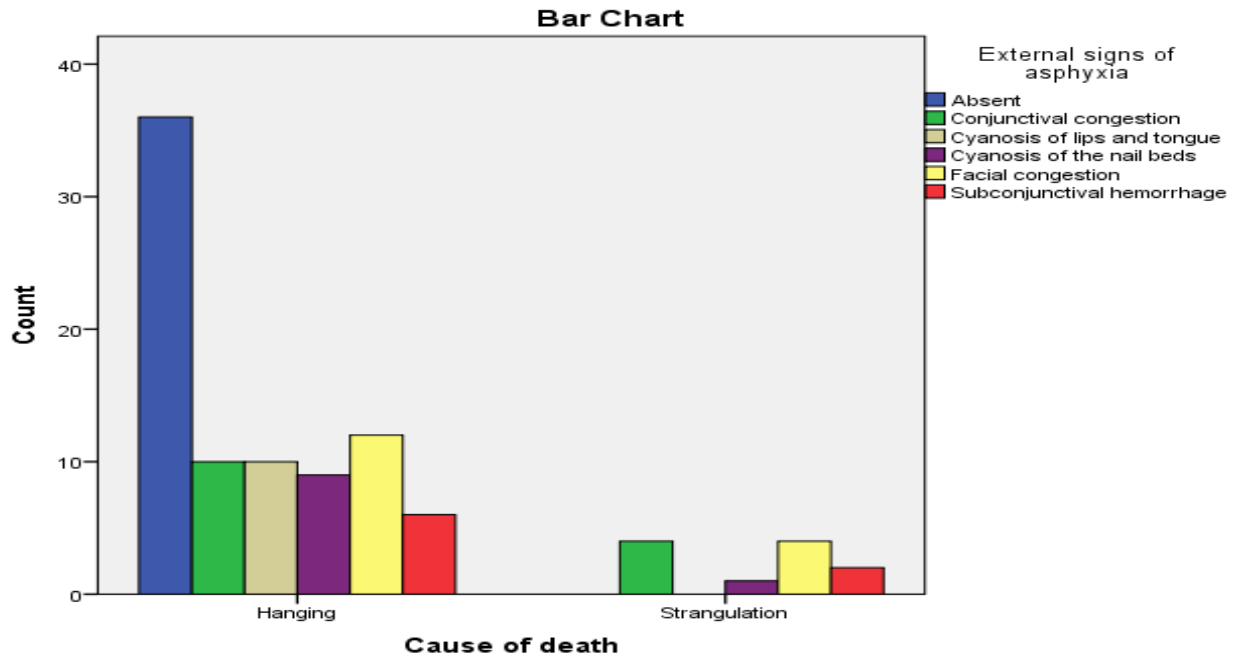


Figure 7: Bar chart, External signs of asphyxia in terms of frequency (n=94)

The commonest internal asphyxia phenomenon was congestion of organ parenchyma which was seen in 11 (100%) cases of strangulation and in the majority (66, 79.5%) of hanging cases; hemorrhagic spots on the lungs and heart were also common being recorded in 47 (56.6%) of hanging cases and in 4 (36.4%) of strangulation cases. Other internal asphyxial phenomena such as hemorrhages of the gingiva, root of the tongue and epiglottis were not seen in any of the cases.

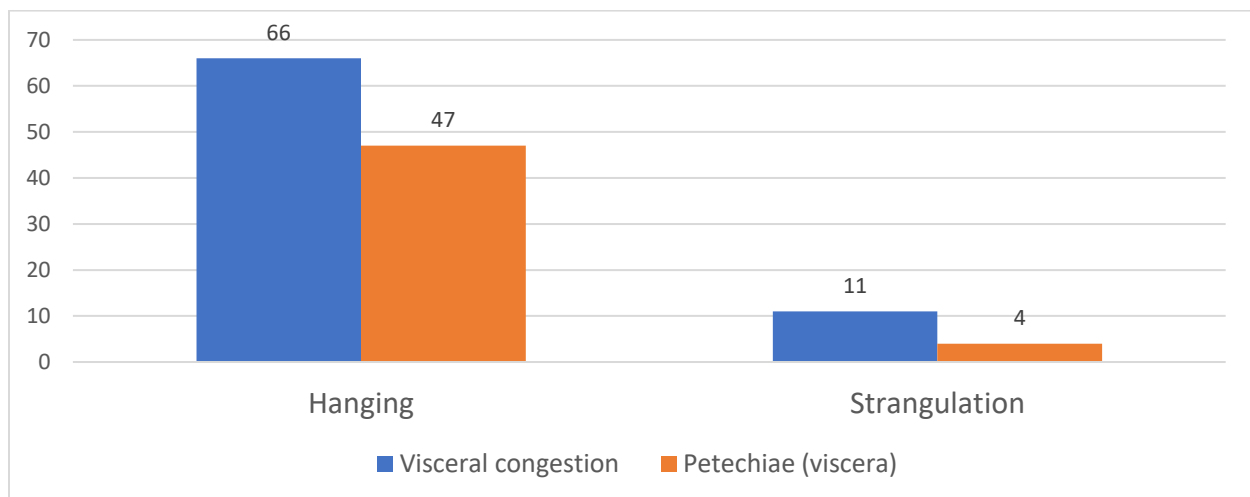


Figure 8: Stacked column, Cause of death and internal asphyxial signs (n=94)

N.B. Visceral congestion were mostly of the brain, lungs and liver.

Face: associated findings

In hanging cases, the tongue was found protruded in 20 (24.1%) cases and dried salivary stains were found in 8 (9.6%) as compared to 2 (18.2%) cases of tongue protrusions and nil dried salivary stains in victims strangled to death.

Table 10: Cause of death and face (associated findings) (n=94)

			Face				Total
			Both	Absent	Dried salivary stains	Tongue protrusion	
Cause of death	Hanging	Count	1	55	7	20	83
		% within Cause of death	1.2%	66.3%	8.4%	24.1%	100.0%
	Strangulation	Count	0	9	0	2	11
		% within Cause of death	0.0%	81.8%	0.0%	18.2%	100.0%
Total		Count	1	64	7	22	94
		% within Cause of death	1.1%	68.1%	7.4%	23.4%	100.0%

Postmortem staining

In hanging, postmortem staining or lividity was found over the back of the body in 64 (77.1%) cases and over the lower parts of extremities in 17 (20.5%) as compared to no cases with postmortem staining over the lower extremities in strangled victims.

Table 11: Cause of death and postmortem staining cross tabulation (n=94)

			PM staining					Total
			Absent	Lower part of extremities	Not visible	Over the back	Over the front of the body	
Cause of death	Hanging	Count	1	17	1	64	0	83
		% within COD	1.2%	20.5%	1.2%	77.1%	0.0%	100.0%
	Strangulation	Count	0	0	0	10	1	11
		% within COD	0.0%	0.0%	0.0%	90.9%	9.1%	100.0%
Total		Count	1	17	1	74	1	94
		% within COD	1.1%	18.1%	1.1%	78.7%	1.1%	100.0%

Injuries to internal neck structures

Contusion of underlying neck muscles was observed only in 4 (4.8%) of hanging cases and in majority of strangulation cases (8, 72.7%).

Table 12: Cause of death and contusion of underlying neck muscles (n=94)

			Contusion of underlying neck muscles		Total
			Absent	Present	
Cause of death	Hanging	Count	79	4	83
		% within Cause of death	95.2%	4.8%	100.0%
	Strangulation	Count	3	8	11
		% within Cause of death	27.3%	72.7%	100.0%
Total		Count	80	14	94
		% within Cause of death	85.1%	14.9%	100.0%

N.B. The most affected muscles in hanging cases were sternocleidomastoid and thyrohyoid muscles, which were observed in 3 (3.6%) and 2 (2.4%) cases respectively; Similarly, sternocleidomastoid and thyrohyoid muscles were frequently involved in strangulation deaths accounting for 5 (45.5%) and 4 (36.4%) cases respectively. Sternothyroid, omohyoid and mylohyoid were also involved.

Fracture of neck structures

In hanging deaths with fracture, the commonest was hyoid bone fracture followed by thyroid horn fracture accounting for 9 (10.8%) and 3 (3.6%) of the cases respectively. Similarly, hyoid bone fracture and thyroid horn fracture were the most frequently involved in strangulation cases accounting for 4 (36.4%) cases each. Thyroid and cricoid cartilages fractures were seen in 1 case of manual strangulation and cervical spine fracture was seen in 1 case of hanging.

Table 13: Cause of death and fracture of neck structures (n=94)

			Hyoid bone fracture	Thyroid horn fracture	Thyroid cartilage fracture	Cricoid cartilage fracture	Cervical spine fracture
Cause of death	Hanging (n=83)	Count % within Cause of death	9 10.8%	3 3.6%	0 0%	0 0%	1 1.2%
	Strangulation (n=11)	Count % within Cause of death	4 36.4%	4 36.4%	1 9%	1 9%	0 0%
Total (n=94)		Count % within Cause of death	13 13.8%	7 7.4%	1 1%	1 1%	1 1%

N.B. The commonest site of hyoid bone fracture in both hanging and strangulation cases was the greater horn at junction of the proximal 2/3 and distal 1/3 with the only other location observed being at the junction of the body and greater horn in 2 cases of hanging; All thyroid horn fractures involved the superior horn.

Table 14: Hyoid bone fracture and age (n=94)

Hyoid bone fracture				Cause of death	
				Hanging	Strangulation
Present	Age group	11-20	Count	0	1
		21-30	Count	3	1
		31-40	Count	1	1
		41-50	Count	2	0
		51 and older	Count	3	1
	Total Count			9	4

6. Discussions

Of the total 2016 post-mortems done during April, 2021 to November, 2021, the number of deaths due to external compression of neck were 94 cases (4.66%) of either sex between 3 days old neonate and 70 years of age elderly. Of these hanging accounted for 83 (88%) of cases while strangulation accounting for 11 (12%) of cases (ligature strangulation being 5.3% and throttling/manual strangulation being 6.7%).

In hanging, it was observed that 69.9% were males and 30.1% were females as compared to the 45.5% males and 54.5% females in strangulation cases. The male to female ratio was 2.32:1 and 1:1.2 for victims of hanging and strangulation respectively. Similar findings were reported by Ma Jianlong et al (2016) ^[12], where the male to female ratio for victims of hanging & strangulation respectively was 2.5:1 & 1:2.6, Boyal RK et al (2019) ^[8] 2.75:1 & 1:4 and Patel JB et al (2015) ^[9] 1.3:1 & 1:2. Pathak Ak et al (2020) ^[14], Singh NK et al ^[8](2018) and Momin SG et al ^[15](2012) also reported similar findings of male predominance in cases of hanging but also reported male predominance in cases of strangulation which was in contrary to this study. In the present study, more males were victims of hanging but slightly more females were strangled to death and the percentage of females in strangulation as compared to that in hanging was higher.

The most frequently involved age groups in cases of hanging were the 31-40 years old age group (34.9%) closely followed the 21-30 years old age group (32.5%); however, the most frequently involved age group in cases of strangulation was the 21-30 years old age group (27.3%) and the least involved age group being the under 10 years old and 41-50 years old age groups 9.1% each. In hanging, similar findings were reported by Ma Jianlong et al (2016) ^[14],

with the most frequently involved age group being the 31-40 and 21-30 years old age groups (21% each) but the most frequently involved age group was the 21-30 years old age group in studies done by Naik SK ^[18] (2005), Pathak Ak et al (2020) ^[14], Singh NK et al ^[8] (2018) and Momin SG et al ^[15] (2012). In strangulation deaths, findings similar to study was reported by Sheikh et al ^[17] (2001), Naik SK ^[18] (2005), Joshi et al ^[16] (2007), Singh NK et al ^[8] (2018) and Momin SG et al ^[15] (2012) where the maximum number of cases were in the 21-30 years old age group; But Patel JB et al (2015) ^[9] and Pathak Ak et al (2020) ^[14], found the 11-20 years old age group to be the most frequently involved.

Ligature mark

In this study, ligature marks in all 83 (100%) of hanging cases were oblique and ligature marks in ligature strangulations were transverse/horizontal in 3 (60%) and oblique in 2 (40%) of the cases. In hanging, similar findings were reported by Singh NK et al ^[8] (2018) and Momin SG et al ^[15] (2012) with 100% oblique ligature mark but Patel JB et al (2015) ^[9] also reported 4.12% transverse ligature marks in hanging. In ligature strangulations, more or less similar findings were reported by Patel JB et al (2015) ^[9], with 67% oblique and 33% transverse ligature marks but in contrary, Singh NK et al ^[8] (2018) and Momin SG et al ^[15] (2012) reported ligature marks in 100% strangulation cases were transverse or horizontal.

Regarding ligature mark encirclement, 53 (63.4%) of the ligature marks were discontinuous and 30 (36.6%) were continuous in hanging which is comparable to the 3 (60%) discontinuous and 2 (40%) continuous ligature marks seen in ligature strangulation. Almost all of the continuous ligature marks were associated with sliding knots. In hanging, similar findings of a more common discontinuity feature was reported by Patel JB et al (2015) ^[9] 80.4%, Momin

SG et al ^[15] (2012) 80% and Singh NK et al ^[8] (2018) 96.9%. In strangulation cases, in contrary to this study, a very high percentage of continuous ligature mark was reported by Momin SG et al ^[15] (2012) 100%, Singh NK et al ^[8] (2018) 100% and Patel JB et al (2015) ^[9] 67%.

In this study, the level of ligature mark in victims of hanging was in 85.5%, 12% and 2.4% of the cases above, at the level, and below the thyroid cartilage respectively as compared to ligature mark in victims of ligature strangulation which was at the level thyroid cartilage in all 5 (100%) of the cases. In hanging, similar findings were reported by Patel JB et al (2015) ^[9] (67%, 30% and 3%), Pathak Ak et al (2020) ^[14] (84%, 14% and 1.5%), Momin SG et al ^[15] (2012) (80%, 15.5% and 4.4%) and Reddy (2010) ^[7] (80%, 15% and 5%). In strangulation cases, similar findings of 100% ligature mark at the level of thyroid cartilage were reported by Patel JB et al (2015) ^[9] and higher percentage at the same level by Pathak Ak et al (2020) ^[14] (75%), Ma Jianlong et al (2016) ^[12] (42%) but in contrary 100% ligature mark below the level of thyroid cartilage by Momin SG et al ^[15] (2012).

In this study, color of ligature mark was reddish to dark brown in almost all cases of hanging (98.8%) as compared to reddish to dark brown in 3 (60%) cases and pale in 2 (40%) of ligature strangulation; The undersurface of the ligature mark appeared dry, pale and glistening in almost all cases of hanging (n=81, 97.6%) and 2 (2.4%) cases with contused undersurfaces as compared to 2 (40%) cases with contused undersurfaces in ligature strangulation. This finding is more or less similar to that observed by Patel JB et al (2015) ^[9] who reported contusion of subcutaneous tissue in 4.12% hanging & 66.6% strangulation cases and by Singh NK et al ^[8] (2018) who reported that all hanging cases showed dry, pale and glistening subcutaneous tissue and contused subcutaneous tissue in 88.2% of strangulation cases.

Additionally, ligature material was furnished along with the bodies of the victims in only 39 (44.3%) cases with ligature marks, of which, 36 of the ligature materials were brought along with victims of hanging and the rest 3 ligature materials with ligature strangled victims; The most frequently used ligature material in hanging was nylon rope (n=16) and piece of cloth (scarf and towel) in strangled victims. The most frequently observed type of knot was sliding knot in 29 (74%) cases. In hanging cases with ligature materials, 75% had sliding knot and 25% had fixed knot as compared to the 3 cases of ligature strangulation with ligature materials where 33.3% had sliding knot and 66.7% case not knotted.

Injuries other than ligature marks

Injuries present over other parts of body give an idea about the resistance offered by the deceased.^[14] In this study, different external neck injuries other than ligature mark such as small abrasions and nail marks were seen in 3.6% of hanging cases as compared to 63.6% of strangulation cases. Other associated external bodily injuries, ranging from simple abrasions and contusion at different sites of the body to significant contusions of the scalp and other parts, were found in 13.3% of hanging cases and in 81.8% of strangulation cases; It was observed that the more significant injuries were associated with victims who were strangled to death. Unrelated gross pathology was found in only one hanging case (Left ventricular hypertrophy). This finding is similar to that observed by Pathak Ak et al (2020) ^[14] who reported some kind of injury over the body in 33% hanging and 75% of strangulation cases.

Signs of asphyxia and associated findings

Among the external signs of asphyxia found during examination, in hanging cases, the most common feature was facial congestion constituting 14.5%, closely followed by conjunctival congestion and cyanosis of the lips and tongue, each constituting 12%. Similarly, in strangulation cases, the most common features were facial and conjunctival congestions each constituting 36.4% cases, followed subconjunctival hemorrhages which were seen in 18.2% of the cases. All external signs of asphyxia were absent in 43.4% of hanging cases while at least one sign of external asphyxia was recorded in all cases of strangulation. More or less similar findings were reported by Ma Jianlong et al (2016) ^[12] where the most frequent external asphyxial signs were more commonly seen in strangulation (89%) than in hanging (66%).

The commonest internal asphyxia phenomenon was congestion of organ parenchyma which was seen in 11 (100%) cases of strangulation and in the majority (66, 79.5%) of hanging cases; hemorrhagic spots on the lungs and heart were also common being recorded in 47 (56.6%) of hanging cases and in 4 (36.4%) of strangulation cases. This is similar to a study done by Pathak Ak et al (2020) ^[14] who reported visceral congestion to be more common, 100% in strangulation and 92.75% in hanging but in contrary to Ma Jianlong et al (2016) ^[12] who reported hemorrhagic spots on the lungs and heart to be more common, 91.3% in hanging and 84.8% in strangulation.

In hanging cases, the tongue was found protruded in 24.1% cases and dried salivary stains were found in 9.6% as compared to 18.2% cases of tongue protrusions and nil (0%) dried salivary stains in victims strangled to death. Similarly, Patel JB et al (2015) ^[9] and Chand et al (2017) ^[11] reported dried salivary stains in hanging cases only, 28.8% and 48% respectively.

In hanging, postmortem staining or lividity was found over the back of the body in 77.1% cases and over the lower parts of extremities in 20.5% as compared to no cases with postmortem staining over the lower extremities in strangled victims. Based on information gather from police and police request, it was observed that 57.8% of hanging victims were found dead at home and 97.6% in suspended positions. Although almost all hanging victims were found suspended, the higher percentage of postmortem staining being found over the back of the body, indicates the bodies were notice by the relatives or others within few hours (2-4 hrs) of suspension, removed and placed in a prone position. Similar finding was reported by Dekal V et al (2016) ^[19], where postmortem staining was found over the back in 77.4% of hanging cases.

Injuries to internal neck structures

It was observed that contusion of underlying neck muscles was observed only in 4 (4.8%) of hanging cases and in majority of strangulation cases (8, 72.7%). The most affected muscles were sternocleidomastoid and thyrohyoid muscles in hanging as well as strangulation cases, which were observed in 3.6% & 2.4% and 45.5% and 36.4% respectively. Sternothyroid, omohyoid and mylohyoid were also involved but more in strangled victims. Similar findings of staggering higher percentage of neck muscle contusions in strangulation than hanging cases were reported by Ma Jianlong et al (2016) ^[12] (80.7%>47.8%), Pathak Ak et al (2020) ^[14] (61.5%>40.7%) and Chand et al (2017) ^[11] (83.3%>5.7%). It was also observed by Ma Jianlong et al (2016) ^[12] that the most frequently involved neck muscle was sternocleidomastoid in hanging cases but sternohyoid and sternothyroid were for strangulation cases.

Regarding osteocartilagenous neck structures, the commonest was hyoid bone fracture followed by thyroid horn fracture accounting for 9 (10.8%) and 3 (3.6%) of hanging cases respectively. Similarly, hyoid bone fracture and thyroid horn fracture were the most frequently involved in strangulation cases accounting for 4 (36.4%) cases each. Thyroid and cricoid cartilages fractures were seen in 1 case of manual strangulation and cervical spine fracture was seen in 1 case of hanging. Similar findings of frequent fracture of hyoid bone than thyroid cartilage in hanging deaths were reported by Boyal RK et al (2019) ^[8] (4%>0%), Momin SG et al ^[15] (2012) (17.7%>1.1%), Ma Jianlong et al (2016) ^[12] (10.8%>4.3%) and Patel JB et al (2015) ^[9] (1%>0%) but on the contrary Pathak Ak et al (2020) ^[14], Naik SK et al (2005) ^[18] and Modi JP (2012) ^[20] found no hyoid bone fracture from 69, 275 and 500 cases respectively. In deaths due to strangulation, more or less similar findings of higher incidence of thyroid cartilage fractures in cases of strangulation than hanging were reported by Momin SG et al ^[15] (2012) (28.56%>1.1%), Chand et al (2017) ^[11] (20%>3.84%), Pathak Ak et al (2020) ^[14] (100%>0%) and Patel JB et al (2015) ^[9] (33.3%>0%). In this study, the percentage of hyoid bone fracture was also higher in strangulation than hanging cases and the same was observed in studies done by Ma Jianlong et al (2016) ^[12] (12.8%>10.8%), Patel JB et al (2015) ^[9] (33.3%>1%), Chand et al (2017) ^[11] (66.7%>1.92%) and Naik SK et al (2005) ^[18] (58.3%>0%) but the contrary was reported by Boyal RK et al (2019) ^[8] (0%<4%) and Momin SG et al ^[15] (2012) (0%<17.7%).

Naik SK et al (2005) stated that though percentage of hyoid bone fracture in manual or ligature strangulation cited by many authors are more or less noncontroversial, the percentage of hyoid bone fracture in hanging deaths vary greatly from 0% to 68% from author to author and high incidence of hyoid bone fracture in hanging as claimed by some authors in this field may be a

result of non-meticulous examination during autopsy and assigning joint mobility between body and greater cornu of hyoid as fracture in addition to improper handling and poor differentiation of post-mortem fracture.

In this study, it was observed that the percentage of hyoid bone fracture in cases of hanging with hyoid bone fracture (n=9) was 44.4% (4) in less than 40 years old and 55.6% (5) in those who were more than 40 years old as compared to 75% (3) in less than 40 years old and 25% (1) in cases of strangulation with hyoid bone fracture (n=4). Although it has been demonstrated in numerous studies that the incidence of fractures increases with age (>40 years) because neck structures become calcified and more brittle in middle and later life ^[19], this study failed to do so and it was concluded that such increasing incidence of hyoid bone fracture after the age of 40 years can probably be demonstrated after taking larger numbers of such cases, which need further continuous study in the future.

7. Conclusion

The present study was planned to establish reliable gross morphological features for differentiating asphyxial deaths due to compression of neck in hanging and strangulation cases since, in practice, the distinction between the two group is very important because strangulation is usually homicidal and hanging in vast majority is considered to be suicidal. ^[6,7] This study showed a wide range of similarities and dissimilarities in finding of hanging and strangulation deaths with the works of other authors.

The conclusion drawn from the present study is, the incidence of asphyxial deaths due to constriction of the neck is more in males as compared to females, and in most of these cases, it is due to hanging.

In hanging cases, male predominance with maximum numbers of cases seen between 31-40 years. The ligature marks were oblique in all, discontinuous and above the thyroid cartilage in the majority of the cases, the undersurfaces dry, pale and glistening in almost all and the ligature material used was nylon rope with sliding knot in most cases. Injuries other than LM were seen in only few cases and those too were not significant. All external signs of asphyxia were absent in nearly half of the cases but internal signs were present in the majority, tongue protrusion was seen in about ¼ of the cases and dried salivary stains in 1/10th of the cases; Postmortem staining over the lower parts of extremities was found in 1/5th of the cases. Contusions of neck muscles were not common and it frequently involved the sternocleidomastoid muscle; Fracture of the hyoid bone was seen more commonly than thyroid horn fracture, no fractures of thyroid or cricoid cartilage was seen and fracture of the cervical spine was rare (seen only in 1 case).

In strangulation cases, slight female predominance with the most vulnerable groups being the 21-30 years old ones. The ligature marks were transverse and discontinuous in more than half, at the level of cartilage in all, the undersurfaces contused in nearly half and the ligature material was soft cloth with no knot in most cases. Injuries other than LM were seen in the majority and those too were significant. At least one external and one internal signs of asphyxia were present in all cases, tongue protrusion was not common and dried salivary stains were absent; Postmortem staining over the lower parts of extremities was not found in any case. Contusions of neck muscles were seen in the majority and although the frequently involved muscle was sternocleidomastoid, the deeper muscles were also commonly involved; Fracture of the hyoid bone was as common as thyroid horn fracture, 1 fracture of thyroid and cricoid cartilages was seen and no fracture of the cervical spine was recorded.

In summary, oblique LM, presence of LM above the thyroid cartilage, undersurface of LM being dry, pale and glistening, absence of external signs of asphyxia, presence of dried salivary stains and absence of contusion of underlying neck muscles are suggestive of hanging while transverse LM, presence of LM at the level of thyroid cartilage, contused undersurface of LM and presence of contusions of underlying neck muscles especially the deep ones are suggestive of strangulation.

8. Strengths and limitations

The strength of this study is that it provided an overview of almost all postmortem findings that are seen in cases of fatal neck compression and compared the hanging and strangulation groups thoroughly.

The limitations include:

1. The number of deaths due to strangulation being very small in comparison to hanging (as have been observed from the reviewed literatures and the data from our department), this resulted in lack of variations of the features ought to be observed which in turn creates a gap in generalizing findings.
2. Due to lack of toxicology facility in Ethiopia, no investigation could be done in this regard. Thus, the role of drugs and/or alcohol play in fatal neck compression could not be demonstrated.
3. Lack of instruments to perform pre-autopsy radiographs especially for assessing fractures of the thyrohyoid complex can raise questions as to the reliability of the figures that were observed in the study in this regard.

9. Recommendation

If there is any chance for such studies to get international recognitions, there should be a certain protocol for examination of fatal neck compression cases which consist of pre-autopsy radiography, palpation of the thyrohyoid complex before en masse removal, bloodless dissection of the neck, careful evisceration, separating the individual neck skeletons for detailed examination and confirmation by histology before cataloging fractures as antemortem. And the institution plus other stakeholders should know that instruments like portable X-ray and machines for toxicological analysis are basic for most of postmortems performed and they should not be considered as a fancy and luxury requirements. Thus, they should work fast towards the provision of these vital instruments to increase the accuracy and qualities of postmortems conducted.

When requesting ML autopsies, ligature materials were not submitted by the investigating authorities along with the deceased in more than half of the cases (56.6%). Therefore, this should be communicated to the legal authorities to submit such vital evidences during the postmortem since their absence can affect the opinion given about cause of death especially in highly decomposed and skeletonized bodies where other features could not be appreciated very well.

After completing this study and reviewing ample literatures in this regard, there are summation of features that can suggest whether to go with hanging or strangulation (can provide useful information, especially when there is incomplete information as to the circumstances surrounding death or crime scene investigation is ambiguous) but none are specific and different studies have put significantly contradicting findings. Thus, it is vital to collect

information about the circumstances of death as well as do crime scene visits whenever possible and corroborate it with the carefully done postmortem examination.

Based on the above recommendation, policy makers should see the importance of investigating officers working jointly with forensic medicine and toxicology experts in solving crimes. Thus, to make crime scene visits possible, the number of these forensic experts should be increased in different regions of the country, necessary fundings should be provided and necessary training should be given to investigating officers as to how to handle evidences and that these evidences are also important to the one performing postmortem examinations and should be provided the earliest possible.

10. References

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10. Annexes

10.1 Selected autopsy cases

10.1.1 Case 1

PME No. – 2598/21 dated 31/10/2021

Brief history: 38 years old, male; Found dead, hung at home on 30/10/2021.

Pertinent postmortem findings:

External – Yellow nylon rope with sliding knot in-situ; A discontinuous, oblique ligature mark above the thyroid cartilage – undersurface is dry, pale and glistening.

Internal – Brain is congested; No contusion and no fracture of internal neck structures.

Cause of death: Hanging.



Figure 9: Pictures, Case 1 (PME No. 2598/21) autopsied at FMT department, SPHMMC, A.A, Ethiopia

10.1.2 Case 2

PME No. – 820/21 dated 06/04/2021.

Brief history: 28 years old, female; Found dead, hung on 05/04/2021.

Pertinent postmortem findings:

External – A green nylon rope with sliding knot in-situ; A continuous, oblique ligature mark above the thyroid cartilage – undersurface is dry, pale and glistening.

Internal – No contusion of underlying neck muscles and no fracture of the thyrohyoid complex.

Cause of death: Hanging.



Figure 10: Pictures, Case 2 (PME No. 820/21) autopsied at FMT department, SPHMMC, A.A, Ethiopia

10.1.3 Case 3

PME No. – 1076/21 dated on 28/04/2021

Brief history: 25 years old, male; Found dead, hung at home on 26/04/2021

Pertinent postmortem findings:

External – A discontinuous, oblique ligature mark above the thyroid cartilage – undersurface is dry, pale and glistening.

Internal – Right greater horn is fractured and dislocated at its junction with the body.

Petechial hemorrhages over the anterior surface of the heart

Cause of death: Hanging



Figure 11: Pictures, Case 3 (PME No. 1076/21) autopsied at FMT department, SPHMMC, A.A, Ethiopia

10.1.4 Case 4

PME No. – 1139/21 dated 04/05/2021

Brief history: 35 years old, male; Found dead, hung on 03/05/2021.

Pertinent postmortem findings:

External – A discontinuous, oblique ligature mark above the thyroid cartilage – undersurface is dry, pale and glistening.

Internal – Internal organs are congested; No contusion of underlying neck muscles and no fracture of the thyrohyoid complex.

Cause of death: Hanging.



Figure 12: Picture, Case 4 (PME No. 1139/21) autopsied at FMT department, SPHMMC, A.A, Ethiopia

10.1.5 Case 5

PME No. – 2122/21 dated 30/08/2021.

Brief history: 16 years old, female; Found dead, hung at home on 29/08/2021.

Pertinent postmortem findings:

External – Eyes are congested with subconjunctival hemorrhage; Tongue is protruded. A shoelace with sliding knot in-situ; A discontinuous, oblique ligature mark above the thyroid cartilage – undersurface is dry, pale and glistening. Hyoid bone is intact.

Internal – Brain and lungs are congested. Petechial hemorrhages over the lungs & heart.

Cause of death: Hanging.



Figure 13: Pictures, Case 5 (PME No. 2122/21) autopsied at FMT department, SPHMMC,

A.A, Ethiopia

10.1.6 Case 6

PME No. – 2399/21 dated 29/09/2021.

Brief history: 14 years old, male; Found dead, hung on 28/09/2021.

Pertinent postmortem findings:

External – Eyes are congested, tongue protruded and dried salivary stains on the left side. A discontinuous, oblique ligature mark at the thyroid cartilage – undersurface is contused.

Internal – Brain, lungs and liver are congested. The right SCM muscle is contused.



Cause of death: Hanging.

Figure 14: Pictures, Case 6 (PME No. 2399/21) autopsied at FMT department, SPHMMC, A.A, Ethiopia

10.1.7 Case 7

PME No. – 2700/21 dated 14/11/2021

Brief history: 60 years old female; Found dead with her hands, legs and mouth tied with a piece of cloth.

Pertinent postmortem findings:

External – Bluish discoloration of the nail beds. Multiple abrasions over the right side of neck and chin, and an oval contusion over the left submandibular region.

Internal – Brain is congested with patchy subarachnoid hemorrhage; Contusion of the right SCM muscle inward fracture of greater horn of hyoid bone at its junction with the body.

Cause of death: Manual strangulation.



Figure 15: Pictures, Case 2 (PME No. 2700/2021) autopsied at FMT department, SPHMMC,

A.A, Ethiopia

10.1.8 Case 8

PME No. – 1160/21 dated 05/05/2021.

Brief history: 30 years old, male; Found dead in a ditch on 04/05/2021.

Pertinent postmortem findings:

External – Body and cloths are soak with water and mud stained; Abrasions over the forehead and front of chest; A discontinuous, oblique ligature mark at the thyroid cartilage.

Internal – Brain and lungs are edematous; Right thyrohyoid muscle is contused. Left superior thyroid fracture and bilateral AP fracture of greater horn of hyoid on both sides.

Cause of death: Ligature strangulation and drowning.



Figure 16: Pictures, Case 8 (PME No. 1160/21) autopsied at FMT department, SPHMMC,

A.A, Ethiopia

10.1.9 Case 9

PME No. – 1945/21 dated 07/08/2021.

Brief history: 50 years old, male; Found dead in a river on 06/08/2021.

Pertinent postmortem findings:

External – Tongue is protruded; Scarf without a knot is in-situ. A discontinuous, transverse, pale, wide ligature mark at the thyroid cartilage – undersurface is contused.

Internal – Right parietal, right occipital and left temporal regions of the scalp are contused; Lungs and liver are congested. Lower parts of right and left SCM are contused.

Cause of death: Ligature strangulation.



Figure 17: Pictures, Case 9 (PME No. 1945/21) autopsied at FMT department, SPHMMC, A.A, Ethiopia

10.1.10 Case 10

PME No. – 1210/21 dated 10/05/2021.

Brief history: 15 years old, female; She was strangled and died on 09/05/2021.

Pertinent postmortem findings:

External – Dried blood stains over the face; Multiple small abrasions over both outer aspects of the neck, nose and front of abdomen.

Internal – Brain is congested and petechial hemorrhages over the heart; Multiple contusions of right SCM and bilateral contusions of omohyoid, sternohyoid and sternothyroid muscles. Inward fracture of the left greater horn of hyoid at its distal third.

Cause of death: Manual strangulation.



Figure 18: Pictures, Case 10 (PME No. 1210/21) autopsied at FMT department, SPHMMC, A.A, Ethiopia

10.2 Proforma 1

The following proforma was used for collection of information obtained from responsible investigating authorities and/or relatives/friends of the decedent and the examination part was filled by myself and other residents after conduction of complete postmortem examination under supervision of a senior physician.

Decedent's preliminary particulars (to be collected from police request, police, family members or friends)	
PME number	
Age/Sex	
Address	
Place, where the decedent was found dead at	
If found dead at home or outside	
Time and date, when the decedent was found dead	
Position/was the body found suspended or not	
History – 	
Postmortem examination	
Date and time of autopsy	
External examination	
Presence and type of ligature material	
Type of knot	

Tongue protrusion	
Dribbling of saliva	
Site of postmortem lividity	
Other injuries on the neck	
External signs of asphyxia	
Facial congestion	
Conjunctival congestion	
Subconjunctival hemorrhage	
Cyanosis of nail beds	
Others	
Presence of ligature mark	
If ligature mark is present	
Level	
Number of turns	
Continuous / discontinuous	
Oblique or horizontal	
Pale or reddish brown	
Presence of other bodily injuries including defense wounds	
Internal examination	
Visceral congestion	
Petechial hemorrhages	
Unrelated gross pathology	
Neck dissection	
Undersurface of ligature mark: pale/glistening or contused	

Contusion of underlying muscles and exact location of the contusions		
Hyoid bone fracture		
Thyroid horn fracture		
Cervical vertebral fracture		
Conclusion after autopsy		
Cause of death	Hanging	Strangulation
Manner of death, if possible		

10.3 Proforma 2: Information sheet and Consent form

Hello, my name is _____, I am one of the participants who is working on a comparative study of hanging and strangulation cases based on gross postmortem findings, in cases that are brought to the mortuary of St. Paul's Hospital Millennium Medical college.

Purpose of the study – To assert cases as hanging and strangulation based on gross postmortem findings and to assess the sociodemographic profiles of fatalities from hanging and strangulation presented for medicolegal autopsy to the department of FMT, SPHMMC, A.A, Ethiopia.

Risk and benefits – There are no risks to the disbursement of justice for the deceased and you for participating in the study but I need about 10 minutes of your precious time.

Payments for participating – You will not receive any payment for participating in this study.

Confidentiality – The information collected from this study will be kept confidential and it will only be used for research purposes. The information will be stored in a file without any personal identifiers but a code number will be assigned to it.

Right to refusal or withdrawal – You have full right to refuse and/or withdraw from the study at any time. Do you have any questions? May I begin?

Consent form

I am willing to participate in the study after it has been explained to me thoroughly in a language that I understand. Signature _____

Name of interviewer: _____ Signature: _____ Date: _____

Identifiers: PME No. _____

Declaration

I, the undersigned declare that this thesis, titled – A comparative study of hanging and strangulation cases based on gross postmortem findings from April, 2021 G.C. to November, 2021 G.C. in Ethiopia – A cross-sectional study, is my original work in partial fulfillment of the requirement for the postgraduate study in Forensic medicine and toxicology. I also declare that it has never been presented in this or any other university and that all resources and materials used in the thesis have been duly acknowledged.

Resident's Name: Dr. Ferid Hamza, Final year Forensic medicine and toxicology resident

Signature: _____

Date of submission:

This thesis has been submitted for examination with my approval as an advisor.

Advisor Name: Dr. Alula Shibabaw, Assistant professor of Forensic medicine and toxicology

Signature: _____

Date of submission: