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RESEARCH ARTICLE

Clinical profile of medico-legal cases in ophthalmology

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ABSTRACT

Introduction: Ophthalmologists play an important role in the management and fixing of legal responsibility in ocular medicolegal cases (MLCs).

Objective: To describe the clinical profile of ocular medico-legal cases attending the ophthalmic unit at a tertiary care hospital in north India

Methods: Medical records of of ocular MLC from November 2015 to May 2018 were considered. The injuries were categorised as adnexal and globe injuries. The clinical profile was recorded in the clinical record forms and analyzed accordingly.

Results: Hundred and fifty six patients were enrolled in the study of which 88 % (137) were male. The mean age was 31.4 years. The most common mode of injury was assault with fist in 55% (86) of cases. Adnexal injuries were the most common n= 72 (46 %). Lid /periorbital contusion and subconjunctival hemorrhage were the most common presentations among adnexal and globe injuries respectively. Open globe injury occurred in 5% (8), of which all had poor prognosis. Malingering was present in 3 % (4). All presented with profound and sudden loss of vision with bleeding from the eye and 12 % (18) of patients had related preexisting ocular morbidity with the present injury.

Conclusion: Fist injury was the most common cause of trauma to the eye. A substantial number of patients who had adnexal injuries or subconjunctival hemorrhage had good vision, contrary to open globe injuries which resulted in very poor vision.

Recommendation: Medicolegal cases require meticulous eye examination along with clear and concise documentation. It is important to always correlate reduced vision with signs of recent injury and be aware of malingering.

Keywords: Medico-legal case, ophthalmic MLC, ocular trauma

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INTRODUCTION

A medico-legal case (MLC) has been defined as an inflicted injury or disease process where the treating doctor establishes the diagnosis by a thorough history, clinical examination, and investigations and determines responsibility according to the law of the land [1].

Many cases of ocular trauma or illnesses are currently being registered as MLC (medico-legal cases) and present to an ophthalmologist for optimal management and to determine liability as per law. An ophthalmologist's role is to confirm the etiology,

assess the depth of injury, grade the type of injury, and establish the severity of the disability.

OBJECTIVE

To describe the clinical profile of ocular medico-legal cases attending the ophthalmic unit at a tertiary care hospital in north India

MATERIAL AND METHOD

The present study was conducted at a tertiary care ophthalmic center in north India. This was a hospital-based retrospective study. The Institutional Ethics committee approved the study protocol. The medical records of patients registered as ophthalmic MLC from November 2015 to May 2018 were considered. The criteria for labeling a case as a MLC included a history of assault, foul play, or accident (including road traffic accidents), patient's/patient's legal guardian's request to register as MLC and the medical officer's opinion. Clinical findings were recorded in the predesigned proforma and descriptive analysis was done on Epidata software.

The standard protocol for eye examination was adopted at the time of the medico-legal examination. Vision assessment on Snellen's chart, torchlight and slit lamp assisted ocular examination along with dilated fundus examination was done in all cases.

The cases were grouped as adnexal (extraocular involving orbit and lid) and globe injuries. Globe injuries include closed and open globe injuries. A full-thickness wound of the sclera and cornea was defined as "open globe injury (OGI)." "Closed globe injury (CGI)" was defined as one in which no full-thickness wound of the sclera and cornea was present.

Injuries were categorized for medicolegal purposes.

RESULTS

Hundred and fifty six patients were identified as ocular MLC. Eighty eight percent (137) were male. The age ranged from 3-85 years with a Mean ± SD of 31.4±12.8 years. Of this, only10% (16) were less than 18 years and 5%(7) patients had bilateral eye involvement. The most common mode of injury was assault with fist in 55% (86) of cases, followed by road traffic accident in 12% (19), wooden stick injury in 11% (17)and metal rod injury in 6% (9) of patients. Five percent of patients were injured with a sharp object like an axe (n=2), spade (n=2), ballpoint pen, scissors, screwdriver and pointed part of an umbrella. Firearm injuries were seen in 3%, while 8% of injuries were caused by miscellaneous objects such as stones, bricks, belts, utensils, chains, shoes, heavy boxes, nuts and bolts. (Figure 1)

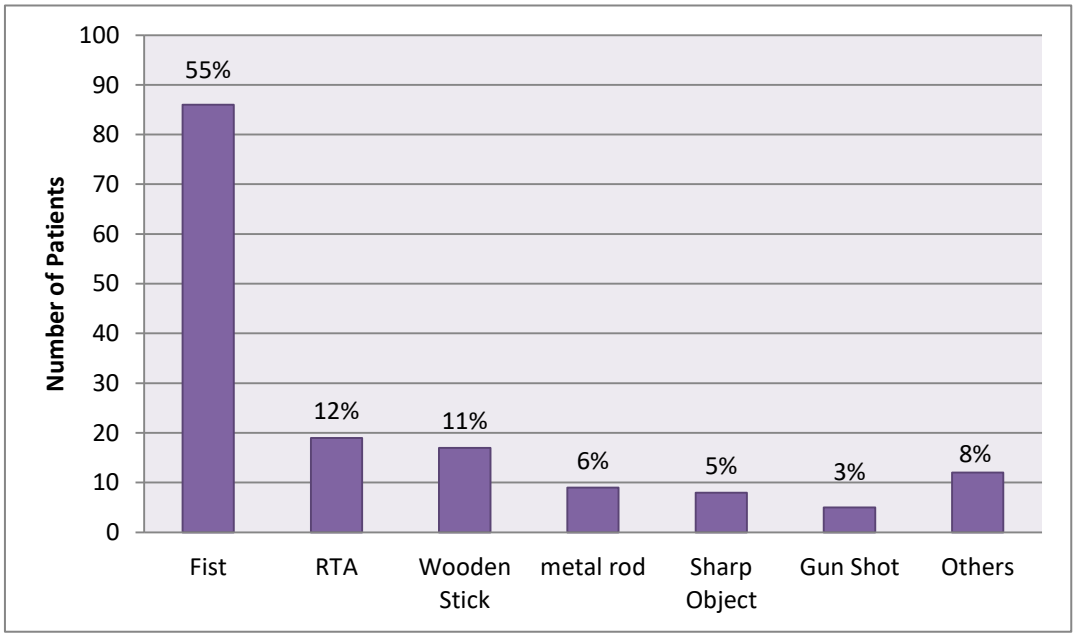

Fig. 1: Mode of Trauma

Workplace injuries accounted for 6 % (9) of cases where four injuries occured due to mishap involving machinery (chain, grinding machine, nut bolt, strap belt in a rolling machine) and five were due to assault at the workplace.

About 30 % (46) and 65 % (101) of cases were recorded from home and outside, respectively. In 68%(106) of cases, assailants were known to the patient and in 14% (22) of cases, there was either no assailant or the injury was unintentional (workplace or RTA).

Adnexal injuries were most common, 46% (72), while globe injuries were present in 30% (46) of cases. Adnexal and globe combined injuries accounted for about 24% (38) of cases. In the present study, the visual acuity of patients was 6/12 or better in 69% (106), 6/60 - <6/12 in 18% (27) and <6/60 in 13% (20). For all patients with open globe injuries, 6%(8) had poor vision (ranging from counting fingers to no perception of light). In 3 patients, vision could not be assessed because of severe head injury. Pain 90% (141), redness 65 % (102), decreased vision 35% (54) and swelling 26% (40) were the major presenting symptoms. Among closed globe injuries, subconjunctival hemorrhage present in 33% (52) was the most common presenting sign. The relative afferent pupillary defect was present in all patients with open globe injury and seven patients with closed globe injury.

Among those with open globe injuriy one had globe rupture, one had corneoscleral tear involving pupillary area, three had corneal tear involving pupillary area, and three had scleral tear. The common ocular presentations following trauma are shown in Table 1.

Table 1: Common traumatic presentations in ocular medico-legal cases

Presentation	% (no.)
Adnexal contusion	45(70)
Subconjunctival hemorrhage	33(52)
Adnexal laceration	18(28)
Traumatic uveitis	05(8)
Hyphaema	05(8)
Traumatic mydriasis	05(7)
Globe penetration	05(7)
Corneal abrasion or foreign body	03(4)
Vitreous hemorrhage	03(4)
Retinal and choroidal hemorrhage	03(4)
Traumatic cataract	02(3)
Macular hole	01(1)
Traumatic optic neuropathy	01(1)
Globe rupture	1%(1)

Among 54 patients who presented with decreased visual acuity due to recent mechanical injury, malingering was present in 3% (4) of patients. In 12% (18), pre-existing ocular morbidity was responsible for decreased vision rather than the recent injury. The typical symptom among malingers was bleeding from the eye associated with vision loss. Their reported vision ranged from counting fingers close to face(CFCF) to no perception of light (NO PL). Table 2 shows the description of pre-existing ocular morbidity, which was claimed to be caused by a recent assault.

Table 2: Frequency of Pre-existing ocular morbidity

Ocular Morbidity	% (no.)
Refractive error	6(9)
Anisometropic amblyopia	1(2)
Phthisis	1(2)
High myopia	1(1)
Cataract	1(2)
Optic atrophy	1(1)
Old Retinal detachment	1(1)

DISCUSSION

The present study highlighted the patient's clinical profile and ocular presentation in medico-legal cases presenting to the ophthalmic unit at a tertiary care hospital in north India. The most common mode of injury in the present study was assault with fist. Adnexal injuries were most common, followed by globe injury and combined injuries, respectively. Lid /periorbital contusion and subconjunctival hemorrhage were the most common presentation among adnexal and globe injuries, respectively.

The present study highlighted the importance of meticulous eye examination to rule out malingering and to differentiate pre-existing ocular morbidity from recent injury. It also highlighted that, at times, the final report could not be given immediately, as the patient may require additional investigations and observation to report the definitive diagnosis.

Similar to previous studies on ocular trauma, the present study has also shown male dominance with a male to female ratio of 7:1[5-7]. According to previous studies, a majority of injured patients were young, with an average age of around 30 years[6,7]. In the present study, patient age ranged from 3-85 years with a Mean $\pm$ SD age of 31.4$\pm$12.8 years. In previous studies, the fist has been reported as the most common mode of trauma[6,7].

In the present study too, the most common cause of trauma among medico-legal cases is fist injury (55%), followed by RTA (12%). Road traffic accidents were the 2nd most common mode of injury and had severe threat to life. Adnexal /extraocular injuries form a major group of injuries. Among adnexal injuries, contusion (45%) and adnexal laceration (18%) were the most common presentations. If severe, they can lead to facial disfigurement or functional impairment, leaving a considerable impact on patients' social, personal and psychological welbeing.

Among the injuries involving the globe, subconjunctival hemorrhage was present in 33% of patients and was the most common presentation, followed by traumatic uveitis and hyphaema, which was present in 5% of patients each.

Nearly 84% of patients had vision 6/12or better, similar to previous study[6,7], depicting adnexal and subconjunctival hemorrhage as the most common injury.

Posterior segment involvement in the form of vitreous, choroidal and retinal hemorrhage, traumatic macular hole and traumatic optic neuropathy were documented.

In the present study, a patient with a superficial foreign body developed a central corneal ulcer, leading to decreased vision; similarly, a macular hole was noticed once the vitreous hemorrhage was resolved in one patient. Therefore, a definitive opinion should not be given immediately, patient should be kept under observation with relevant investigations as the visual disability changes till the final outcome. In specific scenarios, though the visual acuity returns to normal following treatment, there is always a risk of severe future complications. Like in the case of traumatic cataract, visual acuity may return to normal following cataract extraction with intraocular lens implantation. However, there is loss of accommodation in young patients and the surgery is also not always free of complications. Similarly, in vitreous hemorrhage and hyphaema, visual acuity may return to normal. However, there is a future risk of complications such as secondary glaucoma, proliferative vitreoretinopathy changes and retinal detachment. Hence despite favourable vision following treatment, such types of injuries are graded as grievous considering the risk associated.

In the present study, in a majority of medico legal cases, the assailant is known. These injuries may be inflicted as a result of revenge, social conflicts, or for financial reasons. Patients complain of decreased vision after recent injury for unfair advantage. This study has also witnessed malingering in 4 patients. All presented with complaints of bleeding from the eye followed by a sudden diminution of vision ranging from counting fingers close to face to no perception of light. On evaluation, these patients were found to have haemorrhage from the conjunctiva or lid. It has been noted that patients attempt to take advantage of such situations by complaining of sudden diminution of vision. This study also documented that around 12% of patients stated pre-existing morbidity as recent injury.

The ophthalmologist should have a comprehensive understanding of the legal aspects involved in these cases and perform a meticulous examination and note all relevant findings objectively along with important negative signs. Any evidence of malingering and signs which differentiate pre-existing illness from the recent injury should be documented appropriately. In some situations the patients insistence has lead the ophthalmologists to perform electrophysiological tests to rule out blindness.

Illustrating the wound diagrammatically with the measurements, determining VA (visual acuity), IOP (Intraocular pressure) and pupillary reaction are essential features of documentation. Such reports must be kept concise and comprehensible, with the doctor's signature and saved for future references. The records should be kept for three years or until the judgement has been given by court[7].

CONCLUSION

Assault by fist is the most common cause of trauma to the eye. A substantial number of patients who had adnexal injuries or subconjunctival hemorrhage had good vision, contrary to open globe injuries, where vision was poor.

RECOMMENDATION

Medico-legal cases require meticulous eye examination along with clear, concise and accurate documentation. It is necessary to correlate reduced vision with signs of recent injury to rule out malingering, pre-existing ocular morbidity and foul play by patients.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

The authors have no conflicts of interests to disclose.

AUTHOR CONTRIBUTIONS

PG: Concept, Design, Data collection, Manuscript preparation, Interpretation; **AS:** Concept, Manuscript review, Literature review; **KR:** Concept, Manuscript review, Literture review.

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REVIEW ARTICLE

Hymenal morphology in children and adolescents following penile-vaginal penetration

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ABSTRACT

The hymenal injuries in adolescents due to penile penetration is more common and more severe than in adults because of the lack of sexual and child birth experience. In a case of rape which has occurred within few days, the medical professional can identify the injuries on genitalia which are supportive of vaginal penetration. But if the child presents at a later stage there may not be any injury or scar to prove sexual abuse.

The paper reviews the contribution of the different examination techniques in identifying the hymenal injuries, different features of an intact hymen, injuries and healing process, which can be expected if the hymen has been penetrated on adolescent children.

The appearance of the normal hymen, hymenal injuries healing process of adolescents are not well documented except deep lacerations and transection through the posterior hymen which leaves evidence of previous injury. Most of the publications conclude with stressing the importance of recording the detailed statement given by the child as medico legal diagnosis of alleged non-acute cases of sexual abuse. Therefore obtaining a detailed history of the incident which is the standard duty of care in managing a victim of sexual abuse is as important as recording and interpretation of the hymenal injuries to help the law to make a judicial judgment. The words like no evidence of penetration, normal hymen and intact hymen should be used with caution.

Keywords: hymenal injuries, adolecents, penile penetration.

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INTRODUCTION

Penetrative Child sexual abuse (PCSA) exists in every level of society leading to numerous long term effects on physical, psychological and social well-being of the child as well as their families. The evaluation of a PCSA victim is traditionally focused on the status of the hymenal membrane[1]. Retrospective studies in Sri Lanka have shown prevalence of sexual abuse among adolescents to be 21.95[2]. In adolescents, the hymenal injuries due to penile penetration is more common and more severe than in adults because of the lack of sexual and child birth experience [3].

Sri Lanka has a National Policy of reporting requirement of child sexual abuse and children are referred to a Judicial Medical Officer (JMO) for medico legal examination. The standard of care in medical evaluation of PCSA victim examination includes obtaining a detailed history of the incident, examination of the body and genitalia and the laboratory investigations. The JMO has a duty to provide medical evidence that can conclusively prove the act of penetration by thoroughly documenting the details of physical injuries.

Therefore the interpretation of findings in the female genitalia is a key component of the medico legal examination for suspected PCSA and the clinical examination by a JMO that supports the statement given by the victim is crucial in proving the crime committed by the defendant.

In a case of rape which has occurred within few days, the medical professional may be able to identify the injuries on genitalia which are supportive of vaginal penetration. But if the child presents at a later stage there may not be any injury or scar on genitalia to prove sexual abuse[4]. A study reported that only 2.2% of abused girls who presented late had diagnostic injuries whereas 21.4% of those were examined acutely had physical injuries[4]. The important fact is that the most child rape cases have a delayed disclosure[6] and according to the a study on predators of delayed disclosure(more than one week after rape) of rape in female adolescents and young adults the delayed age disclosers were in the age group of 12-17 years of age[5]. Therefore by the time the JMO examines the child, the injuries are most likely to heal to a certain extend thereby the interpretation of the non-acute findings of sexual abuse becomes debatable. Also, the interpretation of injuries on hymen is influenced by a variety of factors including the age, hormonal effects, individual variations, time interval between the assault and the evaluation and the examination techniques[6,7,8].

The studies have established that most ano-genital examinations of children and adolescent sexual abuse victims have no definitive evidence of abuse[1,4] or has non-disrupted intact hymen[8]. But the review of these literature revealed that the findings of the hymen of adolescents following rape have been interpreted differently.

The paper reviews different examination techniques used in identifying genital injuries, features of an intact hymen, injuries and healing process, which can be expected if the hymen has been penetrated on adolescent children.

METHOD

Articles published in English language from 1992 to 2018 concerning hymenal injuries in adolescents following penetration were accessed by a Google search on Medline Database. The search words used were "hymenal injuries", "adolescent" and "penile-vaginal penetration".

Different examination techniques

The genital examination of a child is done using several methods and approaches. The victims can be examined in prone knee-to-chest position, supine position with labial separation or labial traction and in lateral decubitus position[1,7,10,11]. The hymenal rim is traced with a cotton tipped applicator moisten with water when the child is in the supine position while a large cotton swab covered by a latex balloon can also be used[8]. The use of a colposcope is a standard at present as it has many advantages like good lighting, magnification and the fact that findings can be documented by obtaining a high quality photographs or video recording with a camera attached to it. [9,11].

McCann in his studies done in 1992 and 2007 has documented that the examination of the hymen using different approaches are important in visualizing the hymenal injuries[7,10]. He further describes that the hymenal injuries which were not visible by the supine labial traction technique were visualized during examination in the prone, knee-chest position while several anterior and lateral hymenal lacerations were only detected during the prone, knee to chest position. Gardner explains that the hymen looks thick when a child is examined at supine position and has been shown to thin out in knee-chest position[10]. While McCann recommends the supine traction and the prone knee chest position to identify changes due to sexual assault, Harmenn et. al. recommends a combination of all three standard techniques: supine position with labial separation or labial traction or knee-chest position which will increase the yield of positive findings to be designated as definitive evidence of sexual abuse[11].

Intact hymen

The hymen is described as a membrane which is thick (oestrogenized) or fine and transparent[10]. The hymenal configurations are described as annular (circumferential), fimbriated (frilly or folded type), cresentic, septate, cribriform, and imperforate and the shape of the intact hymen may change with the age of the child[3].

The clefts or notches, bumps or tags are described as frequent anatomical variations on the circumference of the hymen and are present particularly at 3 and 9 o`clock positions or upper part of the hymen [3,10,12] . The cleft or a notch is defined by authors as an indentation, division or a split at the rim of the hymen. The depth of the cleft

ranged from 0.5 mm to 3 mm from the free end of the hymen and was found in 35% of neonates and.[12] The other anatomical variations described by Harmenn are bumps, mounds and polyp like hymenal tags.[11]

The study on morphology among adolescent girls with and without a history of consensual sexual intercourse revealed that the adolescent girls who have no deep notches in the hymen could still have experienced penile-vaginal penetration, because 52% of the subjects in the study did not have deep notches or complete clefts in the lateral or posterior locations in the hymen. The study concludes that the absence of notches does not rule out previous penetration in an adolescent therefore the term intact should be avoided when describing a hymen that is free of clefts[8]. McCann is of the same opinion stating that calling a hymen 'normal, without evidence of previous injury' need to be exercised with caution[1]. But the posterior rim of the hymen measuring at least 1 mm is always present unless there has been trauma[13]. However, Adams is of the opinion that if the posterior rim of the hymenal tissue is clear and the free end of the hymen can be followed visually from 3 o`clock to 9 o`clock position when the patient is in supine position it is a normal hymen[9].

Hymenal injuries

Different types of injuries to the hymen due to penile-vaginal penetration are described in the literature and the McCann in his publications has described hymenal injuries in detail as abrasions, contusions, lacerations and transections. A contusion is evident as blood blisters, oedema, haematoma, petechiae, and submucosal haemorrheges[1,7]. A blood blister is a small blood filled vesicular lesions and a laceration is described as a breach of hymenal tissue due to an injury. The lacerations were categorized according to the depth. If a laceration penetrated <50% of the width of the hymen it was considered superficial, if it penetrated halfway it was intermediate, if penetration was >50% it was deep.[1]

Medical evidence of penetration of the hymen

While Adams et. al. states that the deep notches and complete clefts at 3 and 9 o`clock positions and on the posterior portion of the hymen is a significant finding in girls with previous penetration[8]. Anderst et. al. states that the definitive findings of hymenal penetration includes a healed hymenal transection in an area between 4 and 8 o`clock positions, a missing segment of hymenal tissue in the posterior half of the hymen or presence of acute injuries[14]. The authors defines a transection as an area on the rim of the hymen that appeared to have been torn through to or nearly to the base of the hymen. The study of differences in hymenal Morphology between adolescent girls with and without a history of consensual sexual intercourse found that deep notches and complete clefts in the hymen at the 3 o`clock or 9 o`clock position as well as in the lateral and posterior rim of the hymen is strongly suggestive of previous penetration[8]. But the reviewed literature concludes that the healed hymenal transaction on the posterior rim of the hymen is a definitive finding of penetration[1,7,15]. While the presence of positive findings supports allegations of prior penetration, their absence does not preclude trauma from having occurred[17].

The width of the hymenal orifice which was once considered as evidence of penetration, now has no informative value as it varies markedly with the child's examination position, the degree of relaxation, the type of the hymen and the tissue oestrogenization[3,10,11]. Harmenn et. al. states that the use of tampons may also cause widening of the hymenal opening without causing injuries on the hymen[11]. Although there are no publications of normal variations of the width of the hymenal rim, the attenuation/narrowing of the hymenal rim is categorized as consistent with penetrative sexual abuse[13,18].

Adams et. al. who measured the posterior rim of the hymen between the edge of the hymen and the base of the hymen where it meets the vestibular fossa inferiorly identified that the width was 2.5 mm in adolescents with history of consensual intercourse and 3 mm among the group who denied past sexual intercourse. McCann is of the opinion that a width of less than 1 mm of the posterior rim of the hymen is a significant finding of hymnal penetration[1].

Healing process

According to McCann and also other studies the hymeneal injuries in adolescent girls heal rapidly and leave only the slightest evidence of a previous injury [1,4,7,13]. He further describes that minor injuries like abrasions and mild sub mucosal haemorrheges disappear within 3 - 4 days but marked haemorrheges persist for 11-15 days. The petechae which are described as pin head sized lesions resolved in 72 hours. The blood blisters had disappeared in 34 days in adolescents. Abrasions on adolescents have disappeared by day 4 leaving only a localized area of erythema. Most signs of acute

injury disappears within 7-10 days. The author has observed that the oedema and the submucosal haemorrhege affect the depth of the hymen in both ways. When the oedema and sub mucosal haemorrheges subsided the lacerations appear shallower in several cases in his study and the lacerations which was determined as deep at the initial examination was reclassified as transections in follow up examinations[1].

The jagged margins due to the laceration on the hymen smoothed out with the healing process and is difficult to identify[1]. This opinion was supported by Harmenn saying that the V shaped notch or cleft due to trauma may take the shape of a U which is called `concavity`[11]. The edges of the lacerations were rounded off and the narrow hymenal rim at the point of the injury was the persistent findings[1].

Anderst J et. al. whose study was to evaluate the association of definitive hymenal findings with number of episodes of penile-genital penetration detected 80% of victims who provided a history of more than 10 events of penetration had no definitive evidence of penetration on examination of the hymen[15]. Other literature supports a similar view stating that no scar tissues were identified in any of the patients[1] and superficial or intermediate tears healed completely without leaving a scar[11]. The notches of over 50% or transections remain as permanent scars even after several years[3,6,19]. Severe hymenal scars, such as deep notches of over 50% or transections, may remain permanently even after several years[6,19].

It maybe concluded that a detailed history is important in medico legal diagnosis of alleged non-acute sexual abuse in children. Therefore a detailed statement must be recorded from the child.

SUMMARY

The hymenal injuries on children and adolescents heal rapidly and may not leave conclusive evidence of abuse. Definitive evidence of penetration is deep lacerations and full thickness transection through the posterior hymen. Views on the concept of intact hymen, types of injuries and the healing process of hymenal injuries on adolescents following penile-vaginal penetration vary. As the appearance of the hymen is influenced by factors including the examination technique it is advisable to use a multimethod approach to examine hymenal injuries. Opinions like “no evidence of penetration”, “normal hymen” and “intact hymen” should be used with caution. Obtaining and recording a detailed history of the incident is an important component of the medico legal examination of adolescents following penile-vaginal penetration.

LIMITATIONS OF THE STUDY

None

ETHICAL ISSUES

Not obtained

CONFLICTS OF INTEREST

None

AUTHOR CONTRIBUTIONS

JW: Literature review, writing the manuscript, did corrections, type setting

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CASE SERIES

High tension electric trauma at workplaces in Sri Lanka

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ABSTRACT

High tension electrocution causes characteristic injury patterns and sequelae. Work related electric trauma are reported annually with no emphasis on its prevention. The differing patterns of the injuries related to high tension electrocutions are illustrated in this article as three distinctive case reports. The first clinical case is related to the arcing current resulting in bilateral hand amputation while carrying metal pipes in the vicinity of a high tension electric source. In the second instance a plumber whilst inspecting a water tank on the third floor was electrocuted by the overhead high tension power line, initially rendering him unconscious and resulting in death 65 days later. In the third, both the entry and exit wounds were identified due to true electrocution as the victim was touching a side mirror of a crane that in turn was in physical contact with a high tension power line in the process of lifting a transformer. Understanding of the differing mechanisms of causation of these injuries is immensely helpful to clinicians and forensic pathologists in order to provide appropriate treatment as electrocution causes complex, both immediate and delayed onset disease entities. It is helpful also in the interpretation of injury patterns in the process of tracing and reconstructing the succession of events for making compensation claims and for successful preventive strategies.

Keywords: high tension electrocution, injury patterns, delayed onset blindness, arching

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INTRODUCTION

In medical literature, a voltage of more than 1000 Volts, is considered as 'high voltage'. The pathophysiology of high voltage electric trauma is unique[1]. Occupational fatalities due to high tension electric current are occasionally reported in Sri Lanka. Nevertheless, according to the Public Utilities Commission in Sri Lanka there had been 103 fatalities due to electrocution in the year 2019 [2] (not specified whether they were due to high or low voltage electricity). The three case reports presented in this paper describe the mechanisms of injury and their individual pathophysiology. The author presumes that a significant influence towards minimizing such incidents can be made if the workers are made aware and understand the dangers/injuries that they could sustain from working in such high risk environments without adequate protection.

Dangers due to high tension electrocution include death and/or injuries, and the sequelae are multitude in nature resulting sometimes in delayed deaths.

Familiarity with the mechanisms of injury is important to be able to substantially lessen the morbidity and mortality in high voltage electric trauma. Compensation issues may arise in occupational setting and it is the forensic pathologists' duty to help authorities ascertain the manner and cause of death; whether accidental, homicidal or suicide.

Regulations to minimize effects caused by high tension electrocution stipulate a minimum gap between power lines and buildings or construction sites to ensure safety of consumers. It is applicable across Sri Lanka since 2017 and a certificate of safety clearance is required indicating that a safe range both in vertical and horizontal gaps [3, 4] (minimum vertical gap of 2.40 meters and horizontal gap of 1.50 meters for lines up to 1,000 volts, with the distance increasing up to 5.18 meters for high voltage lines of up to 2220,000 volts).

Case 1

A young male was carrying several metal pipes up a staircase from the second to the third floor. The building was situated closer to the high tension electric lines and the staircase also faced that the power line. While carrying the pipes up the staircase, he suddenly felt as if someone was pulling hard on the metal pipes. He was unable to drop them from his grip and he was jerked by the electricity gushing through the pipes along with electric sparks and sudden "burst" followed by flames. As a result, he sustained multiple burn injuries and later, both hands were amputated due to gangrene, following compartment syndrome (Figure 1). During his stay in the ward he developed rhabdomyolysis with no renal failure. The scene investigation concluded that the metal pipes had trespassed the minimum power line clearance causing arcing /flashing which in turn caused burns to the patient with the entry of electric current into his body.

Fig. 1: Bilateral amputation of hands and multiple burns on lower limbs. A patterned burn was seen on the right axilla (causative object not identified).

Case 2

The deceased was a work-assistant installing a transformer. At the time of his death he was holding onto the side-mirror of a crane, whilst the crane-operator was lifting a transformer. History revealed that a large noise was heard with sparks and flames and the victim was thrown on the ground. He lay there lifeless. The crane-operator too was thrown out of the crane onto the ground sustaining minor injuries due to the fall. The driver too claimed to have felt an electric shock. There were entry wounds on the assistant's right hand and multiple exit wounds on his lower limbs despite safety shoes (Figures 2, 3 A & B & 4).

Fig. 2: Palmar aspects of fingers of the right hand with multiple contact wounds (Joule burns) depicting the shape of the object that he was holding while he was electrocuted.

Fig. 3 A & B: The multiple exit wounds on bilateral soles.

Fig. 4: Damage on shoes (indicated with arrows)

Case 3

A plumber climbed onto the roof of a three-story building to inspect a water tank. Suddenly a huge noise and a ball of fire had appeared from the overhead high tension lines and had instantly set his clothes on fire. The plumber was thrown away and sustained significant burns to his body. He was found unconscious and remained so for 36 hours. He was admitted to the ward and managed for 60 days since he had 26% deep burns involving face, back of the chest upper and lower limbs. He was quadriplegic thereafter, and had infected burns which needed to be managed. He was discharged 2 months after in-ward treatment. However, he had been re-admitted 05 days later with complaints of high fever and sudden onset total blindness.

On this second admission, he was diagnosed with bilateral occipital infarcts, frontal lobe infarct, moderate global ischemia (Figure 5) and sepsis. The patient died two days after the second admission. The post-mortem examination revealed few decubitus ulcers (grade 2) and bilateral pneumonic changes and gangrene of right toes (Figure 6 A &B). The cause of death was concluded as sepsis due to effects of high tension electrocution. Upon the site visit by engineers of the Electricity Board, the cause of death was concluded as accidental. In all three cases the possibility of lightening was excluded.

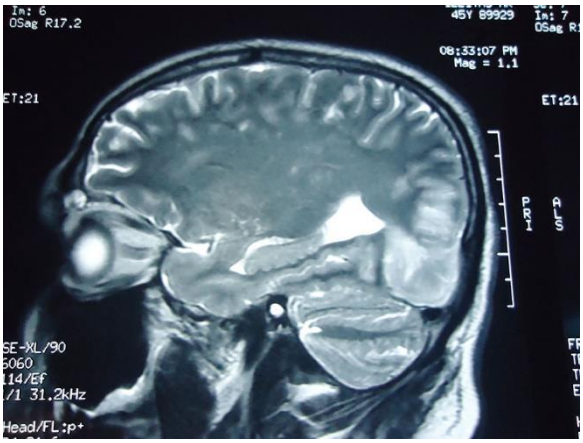

Fig. 5: Bilateral occipital lobe infarction and frontal lobe infarction.

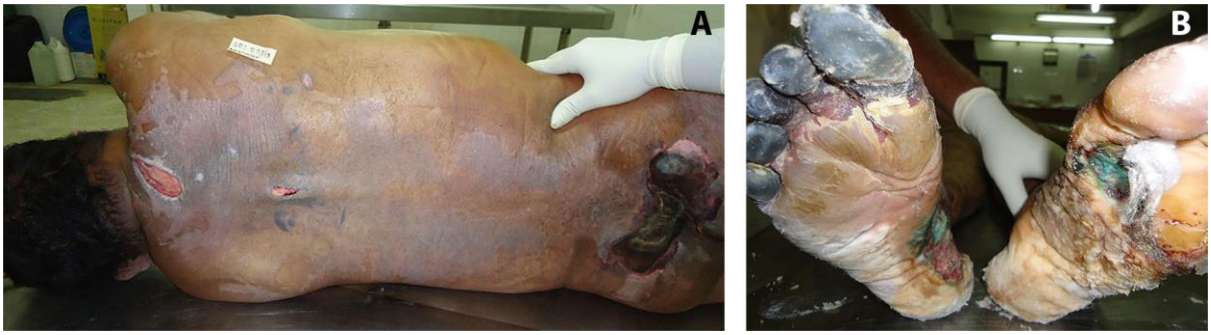

Fig. 6: **A.** Pressure ulcers on back and healed burn scars of burn injuries.
B. Multiple areas of infected burns with gangrenous right toes.

DISCUSSION

High tension electric energy causes many hazardous effects depending on the circumstance, namely electrocution, heat burns, electric shock, arc flash/arc blast, flame and explosions [5]. The resultant damage may be due to true or direct electrical injuries or indirect electrical injuries. In true electrical injuries, the victims themselves become a part of the electrical circuit with entry and exit. However, such injures may be non-recognizable at times because of overwhelming burns. Whereas, in indirect electrical injuries a direct contact is not required [6]. The generated current is delivered to the

person from the source through an electrical arc before actual physical contact. When a body becomes a part of the electrical circuit it makes a reflex response with an entry or exit point and it is loosely named as "shock"[7]. If such an entry brings about the death of a person it is termed as electrocution. When high voltage current ionizes the surrounding gases, the current passes through this medium which was non-conductive, previously[7]. Such current has the highest current density and often luminous forming an electrical arc. When an electric conductor is in close proximity to a human being, such a current can enter the body resulting in electrocution. Such arcs have the potential of causing electro-thermal flash or flame burns in addition to arching electrical burns. Flash injuries only occur when electrical energy travels only through the skin. Such arc /flash give rise to thermal radiation (heat) and intense light, causing burns. The temperature may rise to as high as 50,000 ^{0} C [8]. The rapidly heating air causes pressure waves and thus creates a blast as well. By catching on clothes it gives rise to flame burns as a secondary flame and burn [8].

In the first case the victim had experienced a tetanic effect. According the literature, the indefinite refractory state of the neuromuscular junction causes tetanic contractions resulting in "locking on phenomenon" preventing the victim from voluntary muscle function. However, this phenomenon is mostly applicable to low voltage current though its occurrence is not impossible due to high voltage current[9]. In contrast, in high voltages the throwing down effect is the one that is typically described [8]. Third degree burns had caused his upper limbs to be amputated from the mid-forearm level. He further experienced myoglobinuria, coagulopathy due to the extreme tissue damage and vascular injury by the electrocution. There were superficial burns on his lower limbs and on the right axilla. The burns seen on his axilla (Figure 1) was peculiar with a pattern suggesting a contact burn due to a heated object during the incident. Burns following high tension electric current is a result of many mechanisms; burns as a result of the current passing through the body, flash burns due to thermal radiation and intense heat, contact burns by heated objects and burns due to secondary fire effects such as conflagration of clothing etc. In this case, direct electrocution is not possible but arching is the mechanism that was stipulated. The burns are due to the effects of flash by secondary conflagration and by arcing. According to the opinion of the electric engineer who participated in the scene examination the metal pipes had trespassed the "safety region" and arcing resulted in electrocution.

In the second case, the driver of the crane was thrown away with the sudden explosion while operating the arm of the crane which in turn had accidently contacted the overhead high-tension line. The helper who was standing on the floor suffered fatal electrocution as the current was easily earthed through him. The shoes were not effective in order to prevent the electrocution in this case of high voltage current. The fingers of his right hand showed multiple electric energy entry wounds due to contact with the crane. Multiple exits were evident from both feet[10,11]. The tires of the crane were made of rubber and that is probably the explanation for not having completed the circuit through the driver to bring about fatal electrocution. The low-voltage current usually passes through the lowest resistance but the high voltage current passes through the shortest path irrespective of the tissue type through the body [12]. In low voltage electrocution, usually ventricular fibrillation is the result whereas in high voltage electrocution the mechanism is likely to be ventricular arrest resulting in sudden death[11]. In this case also the poor knowledge and negligence of the driver of the crane had caused the death of his assistant.

In the third case report, considerable flame burns and thermal damage was evident. The deceased had not thought of the immediate danger of arcing from the high tension electric line above while climbing up to the water tank. If he was educated about the danger he could have made some alternative arrangements preventing death.

The effects of high tension current may be immediate or delayed and transient or permanent. Multiple burn injuries maybe caused by flame, flash, arc or a combination. Direct exposure/contact to the current is not evident, and the arc effect was the cause for the injuries sustained. It is evident that the electricity/current had entered his body though it was difficult to determine the exact site of entry and exit wounds. However, it may be speculated that as indicated in figure 6B exit wounds were seen on both soles. Loss of consciousness and quadriplegia indicated immediate involvement of central nervous system. The explanation for the instant quadriplegia was the electro- thermal effects on the spinal cord. The cause for the delayed onset of sudden blindness should also be explained. Literature states that there could be delayed onset phrenic nerve paralysis and electrical cataract and quadriplegia[13-15] upon high tension electrocution. However, to the best of the author's knowledge, delayed onset blindness has not been reported thus far. During the second admission bilateral occipital lobe infarctions along with frontal lobe infarctions were detected. (Figure 5) Blindness

may be explained by occipital infarctions due to thrombosis of already damaged blood vessels with embolization due to high tension electrocution.

The nervous system is the most vulnerable to damage by electric current because of its least resistance, resulting in a high frequency of neurological findings. The passage of electricity through the nervous system facilitates the degeneration of myelin and also causes endothelial damage of vessels which favour microvascular thrombosis impairing the arterial blood supply. Though the delayed onset neurological damage is a well-recognized phenomenon, the exact mechanism is equivocal. The best possible explanation is that this happens due to the combined effects of gradual nerve ischemia secondary to vascular damage and due to the effects of hyper stimulation of neurons [16].

Although the pattern of injuries sustained were different in each of the case reports above, they shared a few points in common: they were male, were breadwinners of their respective families and died or sustained injuries as a result of their respective occupations. Different types of burns were evident in the forms of arc/flash and flame along with true electric injury as observed in the third case report.

Nevertheless, the long term sequelae of electrical exposure is yet to be studied and needs extensive research, in order to understand the exact mechanisms of complications such as delayed onset blindness with temporal and frontal lobe infarctions[17]. A significant amount of workplace accidents are theoretically assumed to be preventable if the workers are provided with proper guidance by using risk indicators such as minimal vertical and horizontal distances from high tension electric wires at least in urban areas.

CONCLUSION

Injuries caused by high voltage electricity, are usually self-evident with the history and examination findings. In addition to direct contact with the power source, arcing causes electric shock and arc/flash burns, as well as flame burns. Due to the high temperature and the explosive effects of the arcing, thermal injuries are also an outcome of such incidents. Variety of outcomes are possible following high voltage electrical current, and as a result injury interpretation by the treating doctor would be useful in appreciating the management plan. Amputation of upper limbs, instant death and delayed deaths with multiple neurological complications emphasize the broader clinical outcomes that ensue upon high tension electrocution. A forensic pathologist should be able to interpret each injury in the context of the broader picture including the history and scene investigations where possible, as performed in the cases discussed herein, in order to reconstruct the incidents or to advice the general public and all stakeholders so that prevention can be the "treatment of choice" for electrical injuries. A strategy to prevent casualties related to workplace high tension electrocution should be addressed in Sri Lanka.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHOR CONTRIBUTIONS

HTDW: Total work done by the author.

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CASE REPORT

Death due to autoerotic asphyxia

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ABSTRACT

Background: Auto erotic asphyxia (AEA) is described as an activity where persons intentionally induces hypoxia in order to increase the sexual excitement. This could be a group or solitary activity, observed commonly in adolescents or yo ung adult males. According to available literature deaths due to autoerotic asphyxia has not been reported in Sri Lanka. This is a case report on the death of a young adult male due to incomplete hanging with sexual paraphernalia.

Case description: A 22 year old male was found partially hanging in his bed room with the door closed. The lower half of the body was naked and he was in an upright kneeling position with a ligature around his neck. The ligature was a cotton sheet with a slipped noose on the right side of the neck and tied a wooden bar under the roof. There was a mobile phone, pieces of a shattered mirror and a chair on the floor close to the body. There was dried seminal fluid on the left hand and on the floor close to the body.

Conclusion: The state of partial hanging was used to reach the state of asphyxia. Prolonged compression of neck or failure to adopt self-rescue mechanisms may have led to death. The findings at the scene correspond to what is reported in the literature on auto erotic asphyxia. This case report highlights the importance of scene visit, in determining manner of death.

Keywords: Auto Erotic Asphyxia, hanging, sexual paraphernalia

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INTRODUCTION

Auto erotic asphyxia (AEA) is described as an activity inducing hypoxia in order to increase the sexual excitement[1]. This may be a group or solitary practice observed commonly on adolescents or young adult males[2]. The findings at the scene of death is unique. It occurs in secluded places and sexual aids like pornographic pictures and videos are commonly seen at the scene. Transvestitism or gaining intense sexual arousal from cross dressing is a common method. While masturbating individuals may fantasize about the fetish objects[2].

According to the available literature, deaths due to autoerotic asphyxia has not been reported in Sri Lanka. Here we present a case where the death of a young adult occurred due to hanging with sexual paraphernalia at the scene. The case report will discuss the classical features of AEA observed at the scene of death.

CASE HISTORY

A 22 year old male was found dead at home where he was living alone. The following were observed during the scene visit, where the body was in situ.

The doors were locked from inside. The body was in the bed room where the windows and the door was closed. He was in an upright kneeling position with a ligature around the neck (Fig. 1). The ligature was a cotton sheet with a slipped noose on the right side of the neck suspended on a wooden bar under the roof. The height of the roof from the floor was 9 feet. The deceased was clad in a T shirt and the lower half of the body was naked. An undergarment was on the floor close to the body (Fig. 2). There was a mobile phone, pieces of a shattered mirror and tumbled chair on the floor, close to the body (Fig. 3). A dried, thick, silver-coloured secretion was seen on the web between left thumb and index finger and on the floor under the body. Search of mobile phone information revealed that the last action was the playing of a pornographic video.

Fig. 1: The body is in the partial hanging position with tumbled chair and mobile phone on the floor

Fig. 2: Partially naked body with the undergarment on the floor.

Fig. 3: Mobile phone and scattered pieces

External examination of the body revealed a congested face, petechial hemorrhages on conjunctivae and fixed hypostasis on the lower half of the forearms, hands, both thighs and front aspects of both legs below knees. There was an imprint abrasion encircling the upper part of the neck on left side which extended upwards towards right from front and back (Fig. 4). The mark was absent on the right side of the neck below the right ear where the knot was present. The body of the hyoid bone was fractured with bleeding into the surrounding soft tissues. Internal examination revealed multiple petechial haemorrhages over the pericardium, and on the lungs. Toxicological screening for alcohol and substance abuse was negative. The swabs obtained from the stains on the finger webs and floor revealed seminal fluid. The sections for histology obtained from the soft tissues around the fractured site showed haemorrhage.

Fig. 4: Imprint abrasion encircling the neck and extending upwards on right side where the knot was situated.

DISCUSSION

Asphyxiation following compression of the neck subsequent to hanging has been reported as the commonest form of AEA[3]. The incomplete hanging position may have been used to create a state of partial asphyxia, but prolonged neck compression or failure of the self- rescue mechanisms led to unconsciousness and death[2]. Asphyxia as a cause of death in the deceased was determined considering the scene, ligature and the ligature mark around the neck, and the presence of congestion and petechial haemorrhages above the ligature mark indicative of compression of neck veins.

The circumstantial evidence demonstrated the engagement of the deceased in autoerotic maneuvers which were observed in other similar case reports. But features like transvestitism, bondage[4] and padding[5] which have been described in the literature were not observed.

Establishing the manner of death, whether accidental or suicidal is a challenging task for the forensic pathologist in these deaths. It becomes difficult due to the unusual methods used by the victims to create the state of partial asphyxia[3]. According to the study conducted by the Arun et al between 5 and 20% of such deaths in US are considered equivocal and most of them are undetermined - whether accidental or suicidal[4]. The possibility of homicide should be ruled out in suspicious cases too. The body was in situ and the doors of the house were locked thereby the determination of the manner of death became easier. This case highlights the irreplaceable importance of the scene visit to determine the manner of death in autoerotic asphyxia. The deceased may have reached the point of suspension standing on the chair. By encircling the ligature around the neck and by keeping the body in partial hanging state may have engaged in sexual activity. The presence of seminal fluid on the hand indicates the act of masturbation. The practitioners knowing the danger of the activity take precautions by creating self-rescue mechanisms[5] which was not observed at the scene. It is possible that he controlled the state of asphyxia by keeping the body in a partially seated position. Prolong compression of the neck or failure of self-rescue mechanisms may have led to hypoxia and an unconscious state resulting in the gravitational drag of the weight of the body causing asphyxia and death.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

None

AUTHOR CONTRIBUTIONS

UGBJ: Did the autopsy. Literature review. Drafted the manuscript; **JW:** Developed and revised the manuscript. Formatted according to the journal guidelines; **LKCDA:** Contributed to the autopsy, scene visit, arriving the cause and the manner of death and the concept of the work.

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CASE REPORT

Death of a young girl with Rapunzel Syndrome

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ABSTRACT

Introduction: Rapunzel Syndrome is an uncommon condition where a trichobezoar is seen at autopsy. This consists of a ball of hair in the stomach, with strands of hair extending like a tail into the small intestine.

Case History: A post-mortem examination was performed on an eleven-year-old girl. History revealed chronic alopecia of over 6-8 months duration with loss of appetite and occasional abdominal pain of 3-4 months duration. She had collapsed suddenly and was pronounced dead on admission to hospital. Autopsy revealed peritonitis secondary to gastric perforation with a trichobezoar in the stomach weighing 600g.

Discussion: Trichobezoars usually remain symptomless until they become large. They are often palpable when they are substantial. It is common in young females, usually with an underlying psychiatric disorder. Various imaging modalities help in the detection of bezoars. The main complications are ulceration, perforation, and obstruction. This condition is rare, but late or missed diagnosis could be fatal.

Conclusions: Even though Rapunzel syndrome is an extremely uncommon variant of trichobezoar, awareness and early suspicion could prevent fatal complications.

Keywords: Alopecia, trichobezoar, Rapunzel's syndrome, gastric perforation, peritonitis

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INTRODUCTION

A bezoar is an indigestible accumulation of foreign material in the gastrointestinal tract. Because of the stomach's large capacity, gastric bezoars do not become symptomatic until they are substantial. The masses are classified according to their contents. Phytobezoars include fruit fibers or plants, lactobezoars are composed of milk, trichobezoars are concretions of hair, and pharmacobezoars are composed of medications.[1] Trichobezoars are rare conditions that consist of hair bundles in the stomach or small bowel. A Trichobezoar is seen in Rapunzel Syndrome, where swallowed hair forms a mass in the stomach with strands extending like a tail into the small intestine.

Infants and children, particularly if mentally disturbed or abnormal, may have a habit of swallowing foreign material, which may lead to the formation of a bezoar in the gastrointestinal tract. Trichotillomania is a condition where the individual pulls out his/her hair from various body sites.

The site from which hair is most frequently pulled is the scalp, but hair may be removed from eyelashes, eyebrows, the pubic region, or other body part. Trichotillomania is usually associated with a condition called trichophagia in which the individual chews and swallows hair.

The condition could go unnoticed for a long time because, on most occasions, it is not witnessed and, even if witnessed, is not considered as pathological. In these cases, loss of hair is the first symptom or complaint. However, often patients are undiagnosed - until it is too late.

Of those with trichobezoars, only 50% give a history of trichophagia. 55% of all bezoars are Trichobezoars.[2] In sporadic cases, strands of hair from the hairball extend through the pylorus, a condition aptly described as "Rapunzel Syndrome".[3] We present a case of an 11-year-old girl who succumbed to this condition where the diagnosis was made at autopsy.

CASE HISTORY

History revealed that the deceased lived with her uncle and aunt as they do not have children. Her parents had separated a few years ago. Even though she had preferred to be alone, her guardians or others had not noticed any abnormal behavior. However, they noticed loss of hair of the victim of about 6-8 months duration. They had sought medical treatment, including a dermatological opinion. Following treatment, the relatives had noticed an apparent improvement but said it recurred after some time.

She has also complained of loss of appetite and occasional abdominal pain of 3-4 months' duration and abdominal distention for one month. Four days before the fatal event, she had complained of constipation.

On the fatal day she had complained of severe abdominal pain with fever and vomiting. Soon after, she collapsed and was rushed to hospital where she was pronounced dead. An inquest was ordered.

An inquest was held where a post-mortem examination was ordered. There was no significant history of any illnesses, including psychiatric conditions. Autopsy performed the following day revealed an averagely built female with mild pallor and dehydration. There were no external injuries suggestive of accidental or intentional trauma. The length of head hair was 30cm, being somewhat sparse with areas of alopecia.

A collection of about 1000ml of yellow coloured purulent fluid was seen in the peritoneal cavity. A perforation was noted on the anterior wall of the stomach close to the lesser curvature in its mid-region (Figure 1). There was a sticky ball of human hair weighing 600g in the stomach (Figure 2). No other abnormalities were seen at autopsy. A small tail of hair was seen extending into the 1st and 2nd part of the duodenum. No other abnormality was detected in the gastrointestinal system or any other system in the body. The cause of death was stated as peritonitis due to perforation of the stomach due to a trichobezoar in the stomach.

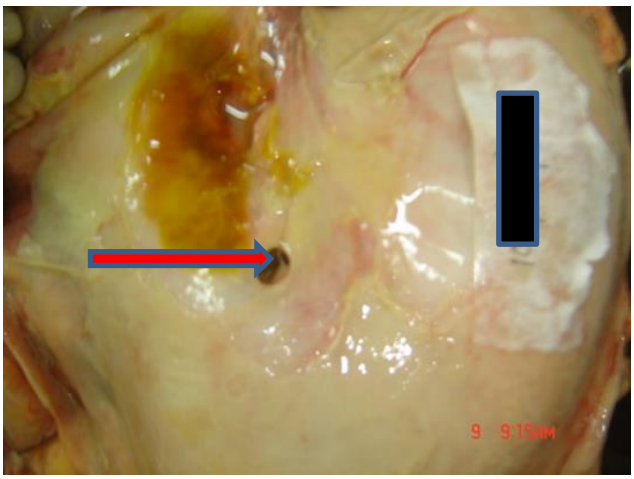

Fig 1: Site of perforation on the outer wall of the stomach (indicated with the arrow)

Fig 2: Trichobezoar in the stomach

DISCUSSION

Bezoar is a collection of foreign material in the intestinal tract. There are many types of bezoars. Trichobezoar is a collection of hair, while Phytobezoar contains vegetable fiber. The term bezoar originates from either Arabic or Persian languages.[4] They are known to give rise to various symptoms and signs mainly related to the gastrointestinal tract.

An important question that needs some explanation is why the condition was not diagnosed until the patient was dead. The reasons are many. The condition which commonly leads to this complication is an illness classified and described under psychiatric disorders. In DSM-5, trichotillomania is classified as Obsessive-Compulsive and Related Disorders.[5] This condition is usually associated with another condition called trichophagia, which means ingestion of hair. Commonly patients present with the complaint of loss of hair. As in this case, they usually seek treatment from family physicians and dermatologists but are not referred to psychiatrists. It is known to be common in young females. When a young female presents with abdominal symptoms accompanied by alopecia and trichophagia, the possibility of trichobezoar should be considered.[6]

Trichobezoars are usually symptomless until they reach a large size. They may present with varied upper gastrointestinal symptoms. Large bezoars are often palpable. However, the asymptomatic and unsuspicious nature of this pathology is mainly responsible for delayed or missed diagnosis. A highly variable and non-specific pattern of alopecia and the presence of other differential diagnoses usually complicates the picture and makes the diagnosis more difficult.

In most instances, trichophagia would go unnoticed or undiagnosed, leading to chronic hair accumulation in the stomach. Human hair usually resists peristaltic movement. It adheres to the stomach wall and gradually grows into a sticky ball of hair.[7,8,9] This often leads to the development of chronic symptoms and signs, mainly of the gastrointestinal system. Complications include bowel obstruction, nausea and vomiting, the sensation of mass and fullness, loss of appetite, and in severe cases, even perforation and bleeding.[10,11] Valencia et al. stated the most common complication of trichobezoar to be either stomach or intestinal perforation.[12]

In this case, the diagnosis of trichobezoar was never considered despite the presence of characteristic symptoms and signs.

Gastric perforation is an infrequent complication of this condition and is said to occur due to high intra-gastric pressure resulting from the bezoar. Chronic stagnation of substances due to accumulating hair could also result in inflammation and infection of the stomach wall rendering it susceptible to perforation.[13] Pressure necrosis is the possible cause of gastric or intestinal perforation. Mortality due to this condition is said to be rare but is associated with perforation of the gastrointestinal tract.

Various imaging modalities help in the detection of bezoars. Computerized tomography with contrast medium is useful in the diagnosis. Furthermore, CT scans could also be used to differentiate the bezoar from other pathologies such as intra- or extra-gastric neoplasms.[14]

Rapunzel syndrome was first described in 1968 by Vaughan et al., who used the term to describe large trichobezoar, found in two teenage girls.[15] Rapunzel syndrome is sporadic, with very few documented cases. The literature review did not reveal any reports of Rapunzel syndrome in Sri Lanka. Also, according to a study where 49 cases from 1968 - 2015 were reviewed, only 3 cases have resulted in a fatal outcome.[16] Awareness of this treatable condition is essential for clinicians to avoid a fatal outcome like this case.

This case also highlights the other medico-legal issues involved with it. Child abuse is a possible differential diagnosis that one should consider. However, in this case, there was no evidence of child abuse. Apart from alopecia, the child appeared to be healthy and normal. The absence of fresh or recent injuries also makes the possibility of child abuse unlikely.

From a preventive viewpoint, the question arises as to whether this case was medically mishandled. However, the nature of the condition and asymptomatic period before the condition gets aggravated is likely to misdirect the clinician, especially when such pathology is very rare. Though the condition was not diagnosed since this condition's incidence is rare and unrecorded in the local literature before this death, a charge of medical negligence is unlikely.

CONCLUSIONS

Even though Rapunzel syndrome is an extremely uncommon variant of trichobezoar, awareness and early suspicion could prevent fatal complications in a young female with chronic hair loss and abdominal pain.

Compliance with Ethical Standards: No conflict of interest. Informed consent was obtained from parents/guardians for useful information for educational purposes with the maintenance of confidentiality of the identity.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

There are no conflicts of interests.

AUTHOR CONTRIBUTIONS

NDNAM: Concept, initial draft, revision, review

YMGIB: Conduct autopsy, approve final manuscript

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CASE REPORT

Fabricated bite mark in a case of assault

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ABSTRACT

Identifying a perpetrator by bite mark analysis is generally based on the detection of tooth impressions that correspond to unique and rare odontological traits.

A 34-year-old female presented with a history of assault where she also claimed that the assailant bit her during the struggle. There was a well defined bite mark on her left forearm along with blunt force injuries on the head. During forensic odontological examination, the wax bite registration of the victim showed several common dental irregularities which were also represented in the bite mark. The location and orientation of the injury also favoured the possibility of self-infliction and no inconsistencies could be found to exclude this bite mark as a fabricated injury in the setting of an assault.

The lack of population specific studies and objective methods of analysis are significant limitations in bite mark analysis. When providing opinion on the identity of the biter, the general recommendation is to use unique features or uncommon irregularities. However, even where only common dental irregularities are seen, a reasonably valid opinion could still be provided using a holistic and deductive approach, if there is sufficient concordance among multiple irregularities with no inconsistencies.

Keywords: Bite mark analysis, Fabricated injuries, Clinical forensic odontology, Injury interpretation

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INTRODUCTION

Bite marks are frequently encountered in forensic practice as hostile bites inflicted mostly during cases of homicide, sexual assault and child abuse.[1,2] Self-inflicted bite marks are occasionally reported either as a component of deliberate self-harm especially in psychiatric patients[3] or as a reactionary response to severe pain.[4] There have also been instances of child abuse[5] and homicide[6] where it is likely that the victim's arm has been pushed against the mouth resulting in bite marks by the victim's own dentition. However, reports on self-inflicted bite marks to fabricate assault are extremely rare.[7]

This case report discusses a recent forensic investigation conducted by the authors where the bite mark analysis and odontological examination of the victim detected a self-inflicted bite mark that was alleged as assault.

CASE REPORT

A clinical and odontological forensic examination was conducted on a 34-year-old female with a history of assault four days prior to the date of examination. She claimed that another female had forcibly entered her home and inflicted multiple blows to her body with a hammer as well as slaps and fist blows to the head and face.

She also claimed that the assailant had pinned her down to the floor and when the victim had tried to push her away, had bitten her left arm. On examination, the alleged victim was conscious and rational. She complained of headache and dizziness and had two lacerations, each 1.5 cm long, on the top of the head and another laceration, 1cm long on the left side of her head. Few scratch abrasions were seen on the chest and lower limbs. A distinct bite mark was noted on the left forearm (Figure 1 and 2).

The bite mark was on the dorsal aspect at mid forearm level. The injury was circular in shape and had a dried brown-red scab. Two arches were distinctly seen orientated obliquely to the longitudinal axis of the forearm.

The arches were separated at their bases with an open space. The radial arch (the arch towards the thumb) consisted of 5 separate indentations with clear separations. A mesial angulation was noted on one indentation. The ulnar arch (the arch towards the ulnar border) consisted of 5 indentations which had tight contact with each other. There were two distinctly deeper indentations with greater scabbing. There were no abrasion marks in relation to the indentations to suggest dragging of teeth across the skin and no overlapping indentations to suggest repetitive biting.

The victim's dentition was recorded and a wax bite registration was obtained (Figure 3).

Fig. 1: The bite mark located on the dorsal surface of the left forearm. No other injuries visible on this arm.

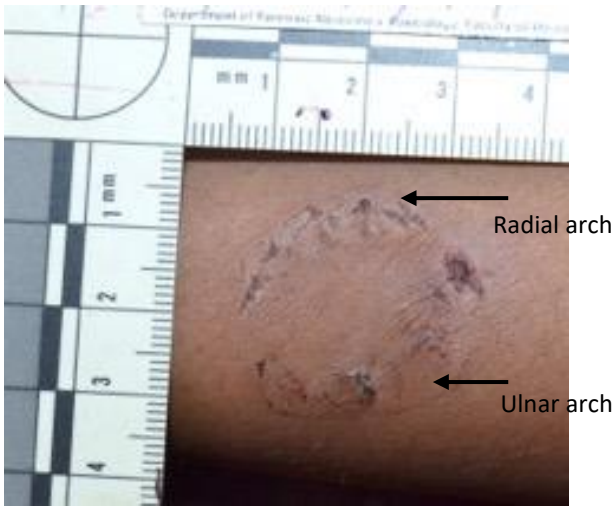

Fig. 2: The bite injury showing two opposing arches with distinct tooth

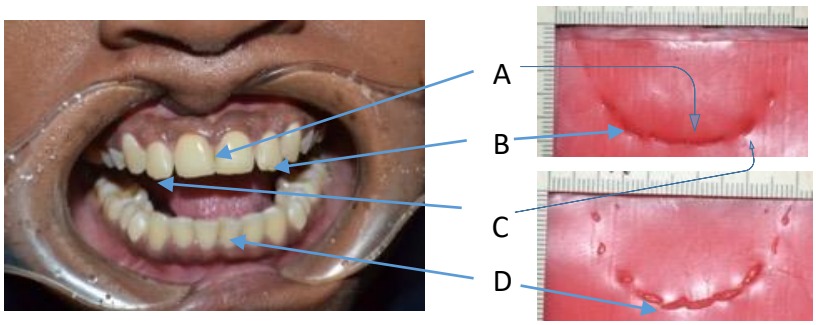

Fig. 3: The victim's dentition and wax bite registration.

A - Tight contact between the central incisors. B & C - Irregular sharp points in the incisal edges of lateral incisor teeth. D - Mesio-angulation of the left central incisor tooth resulting in crowding of the anterior segment

Images of the injury and wax bite registration were imported into the computer programme Adobe Photoshop® and digital transparent overlays were prepared for both upper and lower arches using the wax bite registration. Subsequently the overlays were superimposed over the photograph of the injury. The following comparisons were noted (Figure 4).

1. The curvatures of the maxillary and mandibular arches were similar in shape and size
2. The mesioangulation of the mandibular left central incisor tooth overlapped the angular imprint on the radial arch
3. The two deeper imprints on the ulnar arch overlapped with the sharp points on the incisal edges of the maxillary lateral incisors
4. Compact imprints were noted in the center of the ulnar arch corresponding to the tight contact of the maxillary central incisors.
5. There were no indentations or teeth impressions on the bite mark that did not correspond to the dentition of the victim.

Fig. 4: The bite mark with superimposed overlays of the dental arches. The wax bite registration is also included in the top right hand corner orientated in the same direction as the injury.

The investigators concluded that while the injuries on the head were consistent with an assault, the bite mark showed no inconsistency with a self-infliction. As the injury was more than four days old, no attempt was made to perform a bite mark swab for DNA. Advice was given to the Police to produce the alleged assailant for forensic odontological examination but there was no further communication from either the victim or the law enforcement authorities regarding this case.

DISCUSSION

This is a case where the victim presented with a bite mark claimed to have been inflicted by an assailant during a struggle. She also had other blunt force injuries which were consistent with an assault. However, several dental irregularities found in the victim's own dentition were compatible with the bite mark on her arm and the location and orientation of the injury on the forearm favored a self-infliction which raised the possibility that this was a fabricated bite mark.

Determining whether a bite mark on the skin is self-inflicted or hostile needs careful consideration of the exact location of the injury, its appearance and comparison with the perpetrator's dentition. A large proportion of bite injuries in assaults are inflicted on the arms and hands[1,2] which unfortunately are also a common site for self inflicted injuries. Identifying a perpetrator by a bite mark is considered a difficult and challenging exercise[8,9,10] particularly as there are many published cases of false positives leading to wrongful convictions.[11,12] In general, positive identification is only recommended where there are unique and rare dental anomalies[8,10,11] with no inconsistencies. Testifying on bite mark patterns in courts is often challenging and the use of metric analysis is recommended to provide more objective evidence of dental irregularities.[13]

In this case, the dental irregularities seen in this bite mark would not be considered unique or rare, and there are no population studies in Sri Lanka that provide any quantifiable data on the prevalence of these irregularities. However, the predominant factors here were that the pattern association and the relationship of the irregularities within the dental arch were quite similar between the bite mark and the victim's dentition and no inconsistencies were found. In the authors'

experience, hostile bites on the forearms are often ill defined, haphazardly placed closer to or overriding the ulnar border. Other associated features, such as abrasions resulting from relative movement of the teeth across the skin caused by the victim trying to pull the arm away or overlapping bite marks due to repeated bites are usually seen.[14] However, in this instance, the bite mark was well defined with no abrasion marks or overlapping (bite on bite) marks to suggest that the biting occurred during a struggle. The oblique orientation of the bite mark with the arches being located closer to the radial border are characteristic of an individual biting oneself on the dorsal aspect of the left forearm. The impressions of the radial arch correspond with the dentition of the mandibular arch further supporting this possibility.

Even though these irregularities are common and non-specific on their own, the concordance among all of these features in a single bite mark greatly increases its evidential value. Therefore, based on this collective evidence, we believe that the victim had inflicted this bite mark on herself and subsequently fabricated the history of the biting to escalate the gravity of the assault.

Standard protocols on bite mark analysis rarely emphasize the importance of excluding self-infliction of the bite mark as a preliminary step.[15] This case report is a good example for forensic odontologists to exclude the possibility of self-infliction as early as possible in the investigation process. Guidelines recommend the use of dental impressions to record the features of the suspected perpetrator's dentition in bite mark analysis. However, in this case, the authors found that comparing the wax bite registration with the bite mark was more beneficial in matching the dental irregularities. Obtaining wax bite registration is relatively easy compared to obtaining dental impressions and has demonstrated a high level of accuracy in reproducing common irregularities such as anterior tooth rotations.[13]

Another method that has been proposed, especially in criminal cases, is the use of an integrated technique where, in addition to pattern association, a metric analysis is also performed and compared with population specific data.[16] Such a method would provide more objectivity to the interpretation and minimize observer bias, thereby making the opinion more admissible in court. In countries like Sri Lanka, however, where population specific data are unavailable, the ability of forensic investigators to provide evidence-based opinions especially in situations like this, is greatly restricted. Although there is a high degree of certainty on the identity of the biter in this case, it would be an extremely challenging exercise to prove it in a court of law.

LIMITATIONS

The delay in presentation limited the possibility of DNA testing. The alleged assailant was also not produced to us which would have helped us to further support our interpretation, especially if the assailant had any features which did not correspond with this bite mark. It should be mentioned though, that even if the assailant's features also matched this bite mark, we would still have to state that the bite mark analysis is inconclusive and that we would not be able to exclude this injury as a self-infliction.

CONCLUSION

This case report is an example where a combination of multiple common dental irregularities on a bite mark showed concordance with the victim's own dentition. The location, orientation and appearance of the bite mark also favoured self-infliction more than assault. The alleged assailant was not produced for comparison which was a major limitation in this case, however, even if the assailant was examined, it would not be possible to exclude this injury as a fabricated bite mark since there were no features characteristic of a hostile bite during a struggle and no inconsistencies with the victim's own dentition.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

The authors do not have any conflicts of interest in developing and publishing this manuscript.

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AUTHOR CONTRIBUTIONS

SAG: Conceptualization, literature review, forensic analysis, initial draft, and revision; **JBW:** Odontological data collection, bite mark analysis, literature search and revision of draft.

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CASE REPORT

Marijuana Lung: Radiological, macroscopic and histopathological triptych

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ABSTRACT

"Marijuana lung" refers to a radiological-pathological entity of apical (bullous) paraseptal emphysema in persons who regularly smoke cannabis. We describe a post-mortem case of a drowned young man in whom apical bullous emphysema was seen on post-mortem computed tomography (PMCT) as an incidental finding. Histopathology confirmed the existence of apical paraseptal emphysema. Toxicology, including hair analysis, confirmed that he was a chronic cannabis user. As such this case report can be supportive of the association between chronic cannabis use and the development of paraseptal emphysema.

Keywords: Cannabis, Post-mortem Imaging, Marijuana Lung, Paraseptal Emphysema

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INTRODUCTION

In the western world cannabis is the most widely used illicit drug.[1] It is estimated that 1% of all European adults use cannabis on a daily basis. In Belgium, growing or possessing cannabis remains a crime punishable by a fine or prison sentence. Nevertheless, for the reason of decriminalization, cannabis use is given a 'low prosecution priority'.

Marijuana is the most common form of cannabis. "Marijuana lung" refers to a radiological-pathological entity where there is apical bullous paraseptal emphysema in persons who regularly smoke cannabis.[2] Paraseptal emphysema indicates emphysema bounded by any pleural surface and/or interlobular septa.[3] The current modality of choice for detecting emphysema is computed tomography (CT), with high-resolution CT (HRCT) being particularly effective.

Current literature regarding cannabis use and lung emphysema is mainly based on a radiological and/or clinical perspective. Since this is a forensic case, we had the advantage of also performing toxicological hair analysis to objectify chronic cannabis use. Therefore we could overcome problems associated with self-reporting of illegal substances use.[4]

Case

A body was noticed in a dock in the port of Antwerp. Police identified the person as a 30-year-old Caucasian man and the body was transferred to the forensic department of the University Hospital of Antwerp. This person was known by the police for drug (cannabis) and alcohol misuse previously. Imaging, full autopsy, microscopic examination and toxicological analysis were performed. Urine was positive for tetrahydrocannabinol (THC).

Imaging

Total body CT was performed prior to autopsy. Scan was obtained on a 160 mm detector CT (GE Revolution CT, General Electric, Milwaukee, WI, USA). CT-findings associated with drowning[5] were reported: fluid in the paranasal sinuses, fluid in some mastoid air cells, fluid in the lower airways and ground-glass opacity of the lung parenchyma. Further, paraseptal emphysema limited to the upper lungs was detected (Figure 1A), which is unusual considering the victim's age. The findings suggested the use of cannabis and/or heavy smoking.

In this age group, paraseptal emphysema with risk of spontaneous pneumothorax typically occurs in tall, lean men, especially smokers.[6] Regardless of age, paraseptal emphysema is often seen in patients with chronic obstructive pulmonary diseases (COPD) (and thus often heavy smokers).

Autopsy

This was an adult male with an athletic physique. He had a small laceration on the forehead and there were some bruises on the legs, possibly sustained while in the water. There were no other abnormalities.

On opening the chest, hyperinflated lungs ("kissing lungs") were seen. The chest cavity contained a significant amount of serous pleural fluid. There was pulmonary anthracosis. The left lung weighed 777 g and the right lung 972 g. Both lungs were edematous and congested. The trachea and tracheal bronchi contained white, bubbling froth. The pulmonary vessels were unremarkable. Both lungs showed apical paraseptal emphysema (Figure 1B).

Histology

Apical lung tissue showed paraseptal emphysema. Airspace enlargement with fragmentation of the alveolar walls were seen (Fig. 1C and 1D). The remaining lung fragments, revealed preserved lung tissue with moderate edema, strong interstitial congestion and alveolar wall disruption – *emphysema aquosum*. Histological examination of the other organs were unremarkable.

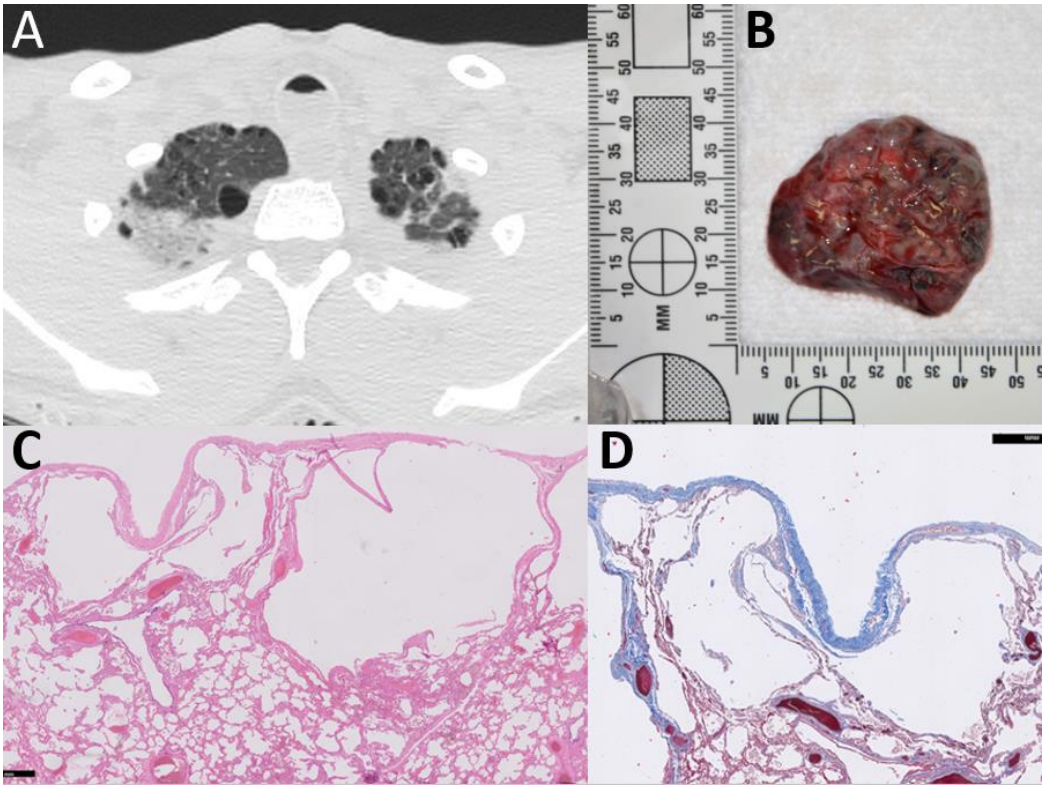

Fig. 1: A Post-mortem CT image of the chest in lung window, demonstrating apical lung emphysema (axial view).
B Apical lung tissue with visible emphysema (axial slice).
C Low magnification photomicrograph of the lung section showing paraseptal emphysema, scale bars 1 mm. (Hematoxylin-eosin stain)
D Low magnification photomicrograph of the lung section showing paraseptal emphysema, scale bars 1 mm. (Trichrome-Masson stain).

Toxicology

Ethanol concentration in blood, urine, and vitreous fluid was respectively 2.8 g/L, 1.3 g/L and 3.2 g/L. Gas chromatography tandem mass spectrometry (GC-MS/MS) revealed 126 ng/mL 11-nor-9-carboxy-delta-9-tetrahydrocannabinol (THC-COOH, the main metabolite of THC) in urine. Post-mortem blood analysis revealed following concentrations: 15.6 ng/mL THC, 7.2 ng/mL 11-hydroxy-THC (11-OH-THC, the active metabolite of THC) and 42 ng/mL THC-COOH. 11-OH-THC and THC-COOH were also found in the liver and kidney. THC-COOH tracing in the 3 cm hair segment was conducted via the procedure published by Van Elsué et al.[7] and revealed a concentration of 18.1 pg/mg. For this value, a 0.20 pg/mg cut-off is maintained by the Society of Hair Testing (SOHT) and a 0.05 pg/mg by the Substance Abuse and Mental Health Services Administration (SAMHSA).

The detection of THC and its active metabolite 11-OH-THC in blood indicates cannabis use in the last hours before death. The high level of THC-COOH indicates regular use. And the detection of THC-COOH in the hair segment indicates regular use in the three months before death. The combined effect of the high quantities of alcohol and THC in blood undoubtedly severely reduced the reactions and alertness of this man, which could have contributed to the fatal outcome.

Autopsy findings and additional technical investigations attributed this death to drowning.

DISCUSSION

The *Cannabis* plant produces cannabinoids that can induce an altered psychoactive state ("high"). THC is the primary psychoactive cannabinoid. Marijuana specifically refers to the leaves, flower parts and viable seeds of the plant and is the most common form of cannabis. Marijuana can be smoked in hand-rolled cigarettes (joints) or in a pipe (bong).

The correlation between smoking cannabis and paraseptal emphysema, specifically in younger patients, has been reported.[2,8,9,10] The exact mechanism for development of emphysema is not well known; a definite causative link has not yet been established. Direct pulmonary toxicity from the components in cannabis itself in combination with airway barotrauma related to the inhalation technique (high inspiratory pressure with prolonged breath-hold) may play a role.[2] The predominant apical involvement may thus be explained by deep inspiratory manoeuvres commonly performed when smoking marijuana.[2,11] The majority of patients, however, are asymptomatic and may only occasionally present with spontaneous pneumothorax (secondary to bullous rupture). Therefore emphysema will mostly be an incidental finding on imaging[12] or during autopsy.

On CT, emphysematous regions are seen as low attenuation areas. There is, however, a relatively poor correlation between autopsy-proven emphysema and CT. Around 20% of pathology-proven cases are not evident on CT.[13] It is recommended to include cannabis (ab)use in the differential diagnosis in all cases of bullous lung emphysema in young individuals.[12]

On the other hand, a recent study from De Bakker et al.[14] re-evaluated 290 PMCT's from deceased aged between 21 and 70 years and found a surprisingly high incidence of small bullae and/or blebs in one third of the cases. However, these authors did not have data on drug use of the deceased.

General microscopic findings of emphysema are airspace enlargement and fragmentation of the alveolar walls. Fiorelli A et al.[9] showed that marijuana users had a higher incidence of inflammatory cells in their lungs, which may favor lung injury and bullae formation. Also, mild fibrotic changes can be seen.[15]

One of the difficulties in proving this causal relationship is that many cannabis users also smoke tobacco, which can also be a cause for paraseptal emphysema in young patients.[2] However, smoking tobacco for a longer period of time is typically associated with more uniformly distributed centrilobular emphysema[10] and the macroscopic emphysema seen at autopsy was neither uniformly distributed, nor centrilobular. The pulmonary anthracosis seen at the autopsy nonetheless, could be an indicator of concomitant cigarette smoking.

As stated above, a definite causative link between smoking cannabis and bullous lung emphysema has not yet been established. Cannabis use is still illegal in most countries. This makes it difficult to collect data from individual users. However, toxicology in our case indicates regular cannabis use and can as such be supportive of the association between cannabis use and paraseptal emphysema.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

The authors do not have any conflicts of interest in developing and publishing this manuscript.

AUTHOR CONTRIBUTIONS

Van Hoyweghen Astrid: Interpreted the post-mortem imaging and Revised the article;
Jacobs Werner: Performed the autopsy and Revised the article;
Neels Hugo: Carried out the toxicological analysis and Revised the article;
Van Goethem Alexia: Reviewed the literature and Drafted the work.

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INNOVATION

Recording volatiles arrested in tissues and body fluids as a tool to reveal crimes against women

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ABSTRACT

Background: Women were symbolized as goddess Shakti (Power) but with modernization our value devastated and now women are objectified on the basis of sexuality. In modern era crime against women including female infanticide, feticide, child- marriage, sexual harassment, rape, kidnapping, threats, intimidation, stalking, cyber stalking, pornography, verbal abuse, physical abuse, prostitution, trafficking, dowry related violence etc. are increasing with time globally. The lack of education, disturbed-patriarchal mindset, loopholes in law and order, low conviction rate are few reasons that give rise to crimes like these and affects lives of millions of women. The main aim of the study is addressing the challenges of detection of major constituent of house hold floor cleaner and cosmetics in biological matrices. The authors have undertaken forensic examination of cases where household substances have been used in violence against women and have observed that detection of such chemical is very challenging. Accordingly, in this paper we have reported two cases emphasizing crimes against women, one case of persistent stalking which leads to suicide and another case of domestic violence related to dowry where in there was an attempt to murder. In both the cases different household volatile substance were used to commit crime.

Methodology: Qualitative and quantitative analyses of substances were carried out by using latest techniques including Gas chromatography - Mass spectroscopy (GC-MS), Headspace-Gas chromatography - Mass spectroscopy (HS-GC-MS).

Results: Alpha-pinene, 3-carene,o-cymene, d-limonene, eucalyptol, gamma-terpinene, ethanol, toluene, p-xylene, fenchone, fenchol, camphene, isoborneol, acetone and methyl alcohol were main compounds which were found during analysis in various forensic exhibits of different cases examined.

Conclusion: With the above mentioned hyphenated chromatographic techniques, various toxic volatiles can be analyzed without the need for additional methods.

Keywords: Crime against women, Gas chromatography - Mass spectroscopy (GC-MS), Head-space-Gas chromatography - Mass spectroscopy (HS-GC-MS), Forensic Science

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BACKGROUND

Indian culture began with the Vedic era. India Carries a chronological record of women being worshipped as goddess that is quite evident in the Holy Scriptures penned down during ancient times. However, her place in society deteriorated in the course of time[1,2]. Changes faced by modern civilization in political, social and economic aspects[1] could be a reason for the degradation of the condition of women in society and increased rate of crime against women such as female infanticide, feticide, molestation, humiliation, eve-teasing,

sexual harassment, rape, kidnapping, vitriolage, intimidation, stalking, cyber stalking, pornography, verbal, physical and economic abuse, domestic violence, prostitution, trafficking, dowry related violence[3,4,5]. The report of the national crime record bureau of India states that 378,277 cases related to crimes against women were reported in 2018 while in 2017 there were 359,849 incidences were reported under this category. The crime rate was 58.8 per 100,000 women in 2018 although in 2017 and 2016 it was 57.9 and 55.5 respectively. According to the National Crime Records Bureau (NCRB) 2018, cruelty by the husband or his relatives was the most common crime against women (31.9%) followed by assault on women with intent to outrage her modesty (27.6%), kidnapping and abduction (22.5%) and rape (10%)[6]. There is a crime of violence recorded against women in India 1.7 minute, a woman is raped every 16 minutes and a woman encounters domestic violence every 4.4 min.[7] The annual crime in India report as published by NCRB after two years delay shows there are 3,59,849 cases of crime against women reported in country [8].

The brutal rape and torture committed on 16 December 2012 on a young 23-year-old medical aspirant[9], created a ripple in the public throughout the nation resulting in Criminal Law (Amendment) Act, 2013 in Indian Penal Codes (IPC). It gave an extensive meaning to rape that was not restricted to sexual intercourse only (Sec. 375 IPC), and also introduced new offences like acid attack (326 A), attempted acid attack (326 B), Sexual Harassment and acting with intent to disrobe women (354 A, 354 B), Voyeurism (354 C) and Stalking (354 D)[10]. Although rape law was amended violence against women did not reduce. Multiple rapes, gang rapes and molestation are being committed by repeat offenders and keep jolting the country.[11-19] The audacity of these criminals is such that they blame the victims for the event[20]. The Unnao Rape Case (U.P.), of 2019 which concerned sexual assault and live burning of a Hyderabad's Veteran (Cyberabad)[21,22] is serious. Globally 35% of women have experienced violence with figures as high as 70% in some countries where they experience abuse and torture of various dimensions. Calls to helplines increased more than 5 times during the covid-19 pandemic which is an indicator of increasing vulnerability of women across the globe. 144 countries have passed laws on domestic violence and 154 countries have laws on sexual harassment. However, data reveals that violence against women has increased significantly in recent years [23]

Volatile compounds (eucalyptol, gamma-terpinene, fenchone, fenchol, camphene, isoborneol) and organic solvents (Ethanol, Methanol, Chloroform, Acetone etc.) that are easily available in households and workplaces or can be brought from a market without a prescription, are widely used in women trafficking, forced sex, bondage, abduction, dowry deaths, date rapes / gang rapes, or for suicide by women suffering trauma[24-26].

The conviction rate i.e. 50 % in 2018 for India with Japan at leading 99.9% [27]. This depicts the lack of scientific approach towards evidence at crime scene and old and classical laboratory analysis procedures that needs to be upgraded. The fast response of the scene of crime team, the proper collection and preservation of the exhibits and the submission of the exhibits to the forensic science laboratory at the earliest, is indispensable for scientific examination and submission of a report in a structured timeframe to the investigating agencies in order to assist the justice system.

The main objective of this manuscript is to emphasise the detection of volatiles (nail polish remover and floor cleaners) used in crimes against women by modern instrumental techniques like GC-MS and HS-GC-MS and to discuss aspects of qualitative identification and intricacies involved in interpretation of result.

Case 1

A 21 year old married woman was admitted to hospital by her family with an alleged history of ingestion of an unknown substance. The remnants of the gastric lavage and a plastic bottle with liquid contents were submitted for forensic examination. The individuals life was saved following gastric lavage. Further investigation revealed that the relationship of victim with her in laws was not harmonious and she was frequently abused emotionally and physically for her inability to bear a child.

Case 2

A 17 year old girl was admitted to hospital by her family in an unconscious state with a history of ingestion of about 100ml of nail polish remover at home. She died during the course of treatment. Investigation revealed that the girl was being stalked and that she may have committed suicide due to this. A post-mortem examination revealed 100 ml whitish liquid in the stomach with yellow discoloration of the stomach wall. Lung, Liver, spleen and kidney were congested. The lower lobe of both lungs revealed multiple consolidations.

On sectioning froth mixed blood oozed out of Viscera (Stomach and its contents, piece of small intestine, liver, kidney and spleen). Femoral blood was preserved for toxicological examination and submitted.

METHODOLOGY

Reagent and apparatus: Anhydrous Ammonium sulphate, acetic acid, ammonia, Sodium tungstate, Diethyl ether, Chloroform, hydrochloric acid (HCl)analytical grade(AR) from Merck. Equipment used included Reference® pipettes with disposable tips (Borosil, India), Hamilton Microlab®503A diluter/dispenser with 1-mL reagent syringe, 100 µL sample syringe (Hamilton, Reno NV) & manual crimper (Agilent), Elga, Flex 2 water purifier and all glassware used were from Borosil.

Biological exhibits (viscera, blood and gastric lavage fluid) were screened using alkaline, acidic and neutral ether extraction, as detailed below. The non-biological exhibits (liquid contents submitted in plastic bottles) were distilled and examined as detailed below. Thin layer chromatography (TLC) was carried out to rule out presence of pesticides and suspected drugs[28]. Qualitative analysis of volatile poisons after distillation was undertaken using hyphenated chromatographic techniques. The details are described below.

Extraction procedure[28]: 50 g of macerated visceral tissues (stomach, intestine, liver, kidney and spleen) were treated with 10 g of anhydrous ammonium sulphate and 10 ml of acetic acid, then subjected to digestion on a water bath for 3 hours at 100 $^{\circ}$C and further screened using alkaline, acidic and neutral ether extraction[28]. 1 ml of blood was diluted with deionized water, treated with a pinch of sodium tungstate and 2 ml of concentrated Hydrochloric acid. The deproteinized blood was extracted and analyzed by TLC.

Distillation procedure: 5 g of visceral tissue added to a conical flask then 5ml of dilute Hydrochloric acid was added into it and set over the distillation apparatus. For analysis of phenolic compounds distillate was collected in 10 ml of 1N sodium hydroxide solution in volumetric flask in ice cooled condition and for other volatiles compound distillate was collected in volumetric flask without sodium hydroxide. Blood and gastric lavage fluid were also distilled by the same procedure. The blank control was also subjected in the all chemical test to rule out any contamination. Nail polish removers and floor cleaners of various brands sold in Delhi, India, purchased from local market were examined for confirmation and comparison.

Thin layer Chromatography (TLC): For these 2 case studies preliminary examination of samples was done using TLC plates (silica gel G 60 F254) activated at 105^{0} C for 30 min. The chamber was saturated for 30 min. The solvent system used for TLC was: Chloroform/Acetone (8:2) and Chloroform/Methanol (9:1). The developed plates were sprayed with suitable reagents to visualize the location of drugs and pesticides[28]. The tests were negative for all the exhibits when screened for drugs and pesticides (data not shown).

Gas Chromatography-Mass Spectroscopy: Agilent 7890B GC with Mass Detector 5977A was used to analyze all the exhibits. The setting of the instrument is as described: Column- HP-5MS(30M x 0.250mm x 0.25µ) Oven Temperature–initially 100 ^{0}C for 1.5min then rate of 7^{0}C /min till 300 °C for 10 min, Injection Temperature - 280°C, Injection volume - 1µL, Mode – Split, Carrier Gas – Helium, Flow Rate – 70.9 ML/min., MSD parameters included EI tune type, temperature of MS source - 300^{0}C, temperature of MS Quad- 150^{0} C, Start Mass- 29.00 End Mass-400. Total run time for a cycle was 25 min. Mass spectral library:- National Institute of Standards and Technology (NIST), NIST MS 2.2 mass spectral library

Headspace-Gas Chromatography-Mass Spectrophotometry: **HSGC-FID/MS method :** An Agilent gas chromatograph coupled with Head Space Sampler, FID and Mass Selective Detector (Agilent Technologies, Wilmington, Delaware, USA) was used for the assay in HS-GC-FID/MS configuration consisting of a GC (Agilent 7890B) equipped with a FID and MS detector (MSD 5977A) coupled to an Agilent (7697A) HS sampler. The Dean's Switch was configured using a 1:1 split ratio to the FID and MS according to the manufacturer's instructions using fused-silica capillary restrictors with dimensions of 1.06 m× 0.18 mm to the FID and 2.89 m × 0.18 mm to the MS. Helium was used as the carrier gas. Separation of analytes by gas chromatography was carried out using a J & W DB-5MS (column 1) capillary column (5% phenylmethylpolysiloxane, 30m × 0.25 mm × 0.25 µm, Agilent). Ionization was accomplished by electron impact (EI) and the MSD operated under selected ion monitoring (SIM) mode. The Headspace parameters (HS) was as follows: the oven maintained at 70 °C, the loop was maintained at 85 °C and the transfer line was maintained at 130 °C. Before injection of the sample, the vials were incubated for 15 min at 70 °C. The injection time was held constant at 1 min. The injection port was

maintained at 150 °C and operated in split mode with split ratio of 30:1, maintaining a pressure of 9.7 psi, septum purge flow of 5 ml/min. The chromatographic gradient (GC) was programmed as follows: an initial oven temperature of 40 °C was held for 6 min and then increased in a linear fashion to 220 °C at 20 °C/min. At the end of each run, the initial temperature was reset to the initial condition. Helium carrier gas (with purity 99.999%), was set to 0.6 mL/min flow rate (column 1) and flow rate for column 2 and 3 were 3.98 and 1.60 mL/min respectively. The FID detector was held at 250 °C. The gas flow rates were as follows hydrogen 40.0 mL/min, air 400.0 mL/min and nitrogen 20.0 mL/min. The nitrogen flow rate was maintained at a constant 15 psi. The GC run time was 15 min. MSD temperature was at 300 °C and MS Quadrupole was maintained at 150 °C, the ionization energy in mass was 70 eV and was scanned from 29 to 400 amu at a rate of 3.0 scans/s. Total run time for HSGC is 30 minutes per sample. To maximize sensitivity, the MSD was auto-tuned by using fluorotributylamine (PFTBA, tuning standard). Ionization of the analytes by electron impact (EI) was obtained using an emission current of 70eV. GC/MS Mass Hunter with MSD Chem Station Data Analysis software (Version B.07.00) was used for data analysis and quantitation.

Sample preparation for Instrumental analysis and quantification of Ethanol and Methanol:

1ml of sample (calibrators, controls, and case samples) was mixed with 90 µl of n-propanol (internal standard) of concentration 21.7 mg/dl and placed in a 20-mL headspace vial with the Hamilton Microlab® 503A diluter/dispenser, crimped and sealed. Quantitation was performed using the response ratio of the FID response of ethanol to n-propanol. One set of positive and negative controls was analyzed prior to case samples and one set immediately after case samples. A five point calibration curve was used to determine the concentration of ethanol and methanol in blood samples. The range of concentration levels for the ethanol 7.9mg/dl to 39.5mg/dl and methanol 15.8 mg/dl to 79mg/dl. Calibration curves were constructed by plotting the mean response ratio (response of analyte/response of n- propanol used as internal standard) against the mean amount ratio (amount of analyte/amount of internal standard) (Figure 1). Ethanol was identified by retention times and target qualifier ions. The calibration curves were linear R(2) ≥ 0.996). Limit of detections and limit of quantifications were calculated on the basis of signal to noise ratio.

RESULT

CASE 1

alpha-pinene, 3-carene,o-cymene, D-limonene, eucalyptol and gamma-terpinene compounds were detected in gastric lavage fluid of the deceased. Along with these compounds, ethanol, toluene, p-xylene, fenchone, fenchol, camphene and isoborneol were detected in bottle which was found at crime scene (Table1, Figure 2A, 2B, & 2C). For preliminary examination, distillate was subjected to various chemical tests. Distillate showed presence of ethanol. A market formulation of floor cleaner was also run to compare with case exhibits. (Figure 2D)

CASE 2

Methanol and acetone were detected in viscera and blood. Ethanol was found only in viscera sample of the deceased. For preliminary examination, distillate was subjected to chemical tests. Distillate showed positive reaction with Legal' test[28], Schiff's reagent test[28] and potassium dichromate test[28]. For this case various brand of floor cleaners were used for comparison. Quantification of methanol was done in blood of deceased through GC-HS. The chromatogram produced clearly indicates the presence of ethanol at retention time (Rt) 3.954 minute, methanol at 3.736 minute. Methanol level in the blood was quantified as 40 mg/100ml of blood n- propanol used as an internal standard elutes at Rt 4.16 minute which is indicative of the fact that our method is well in place. The positive chemical test gave the lead to move for confirmatory test of the target poison through complimentary techniques of GC-HS and HS- GC-MS (Table 1 & Figure 3A,& 3B).

TABLES & FIGURES

Table 1: Results of Case 1 and Case 2

Case No.	Name of detected compound	IUPAC name	Retention time (GC) Min	Peak detected in MS (m/z ratio)	Conc.	LOD/LOQ
Case 1 (Yellow colored turbid liquid)	alpha-pinene	4,6,6-trimethylbicyclo [3.1.1] hept-3-ene	11.613	91.1, 92.1, 77, 79.1, & 121.1.	-	-
	3-carene	4,7,7-trimethylbicyclo [4.1.0] hept-3-ene	12.47	93.1, 77,121.1, 136.1, &105.1.	-	-
	o-cymene	1-methyl-2-propan-2-ylbenzene	12.609	119,134.1,91 & 77	-	-
	D-limonene	1-methyl-4-(1-methylethenyl)-cyclohexene	12.665	93.1,68.1,79.1 &121.1	-	-
	Eucalyptol	2,2,4-trimethyl-3-oxabicyclo [2.2.2] octane	12.717	93.1, 43, 81.1 & 108.1	-	-
	gamma-terpinene	1-methyl-4-propan-2-ylcyclohexa-1,4-diene	12.908	93,91,77, 136.1 &121.1.	-	-
	Ethyl Alcohol	Ethanol	3.954		-	-
	Toluene	Methylbenzene	8.871		-	-
	P-xylene	1,4-Dimethylbenzene	10.696		-	-
	Fenchone	1,3,3-Trimethylbicyclo(2.2.1)heptane-2-one	13.243	81,69, 41 & 152.1	-	-
	Fenchol	(1R,2R 4S)-1,3,3-Trimethyl-2-norbornanol	13.504	81.1, 69, 41 & 93	-	-
	Camphene	2,2-Dimethyl-3-methylidenebicyclo(2.2.1) heptane	11.826	93, 121.1, 107.1, 79 & 67	-	-
	Isoborneol	(1R,2R,4R)-1,7,7-Trimethylbicyclo(2.2.1)heptane-2-ol	13.899	95,93,41,67 & 121.1	-	-
Case 2 Transparent liquid	Methyl Alcohol	Methanol	3.7	31,32,29	40mg/dl	1.58mg/dl 5.2mg/dl
	Acetone	Propan-2-one	4.1	43,58,42, &39	-	-
	Ethyl Alcohol	Ethanol	3.9	31,45	-	0.79mg/dl 2.6mg/dl

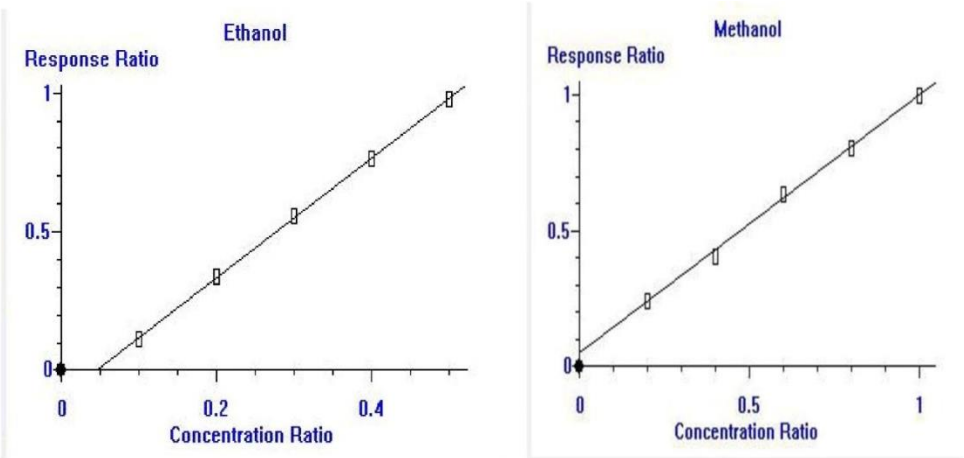


Fig. 1: Calibration curve for Methanol and Ethanol

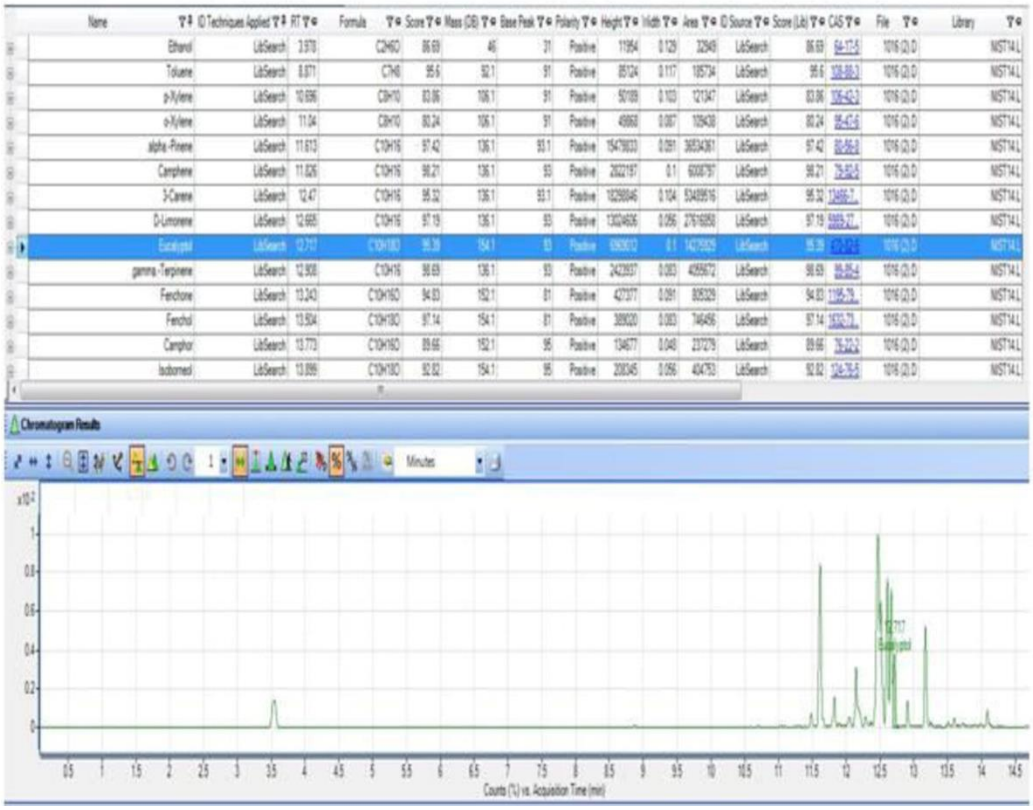


Fig. 2A: Gas Chromatogram (GC-MS) with compounds list of exhibits of case-1

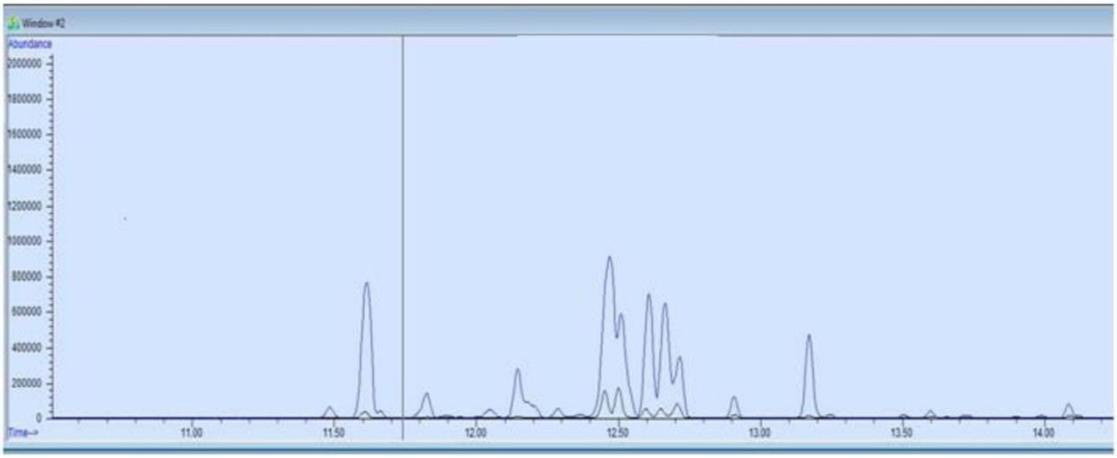


Fig. 2B: Overlay chromatogram (GC-HS-MS) of exhibit 1 and 2 of case-1

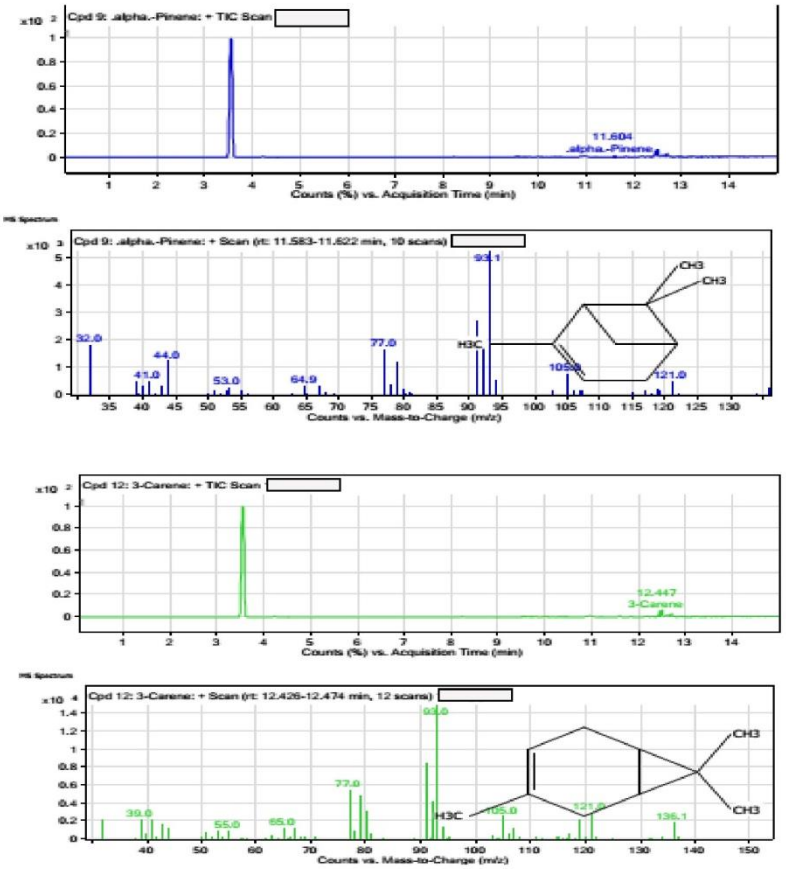


Fig. 2C: Gas-chromatogram (GC-HS-MS) of exhibit of case-1

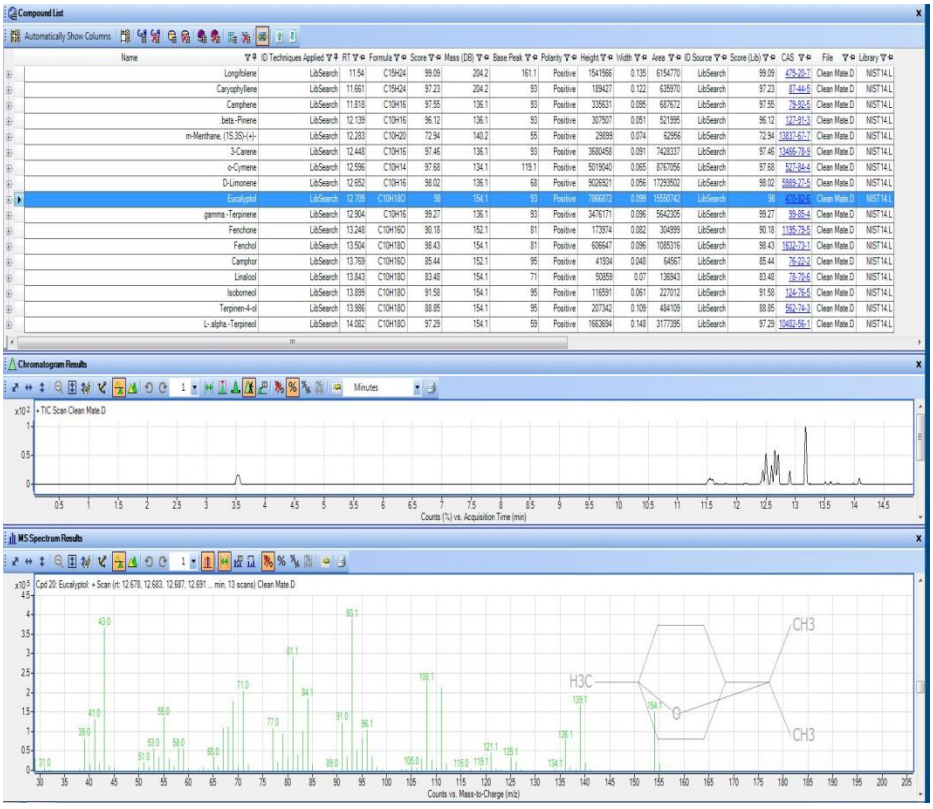


Fig. 2 D: Gas -chromatogram of Standard purchased from local

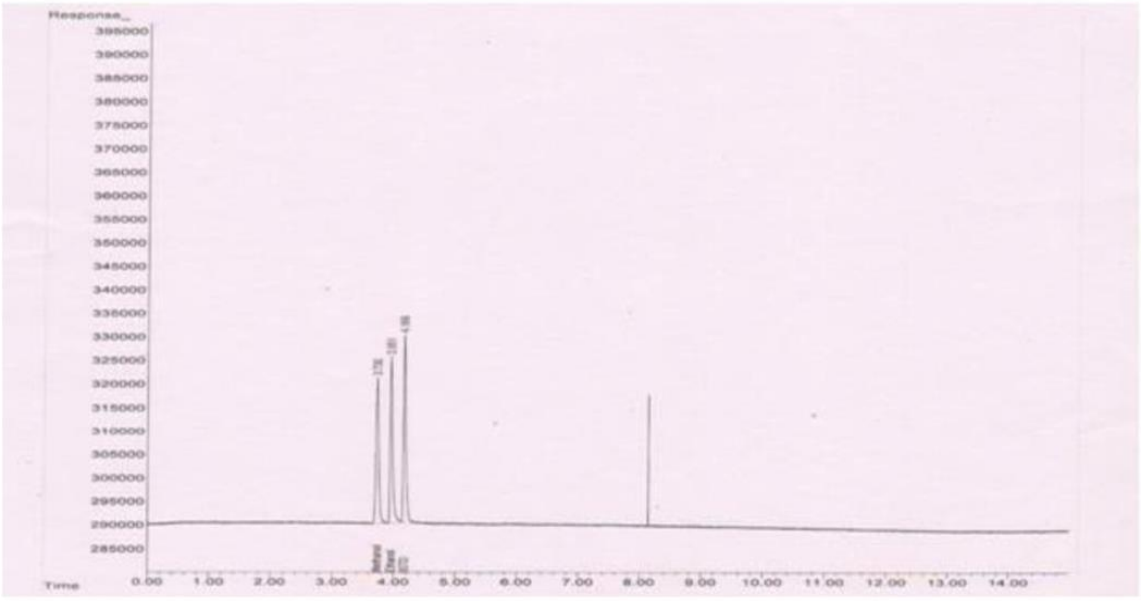
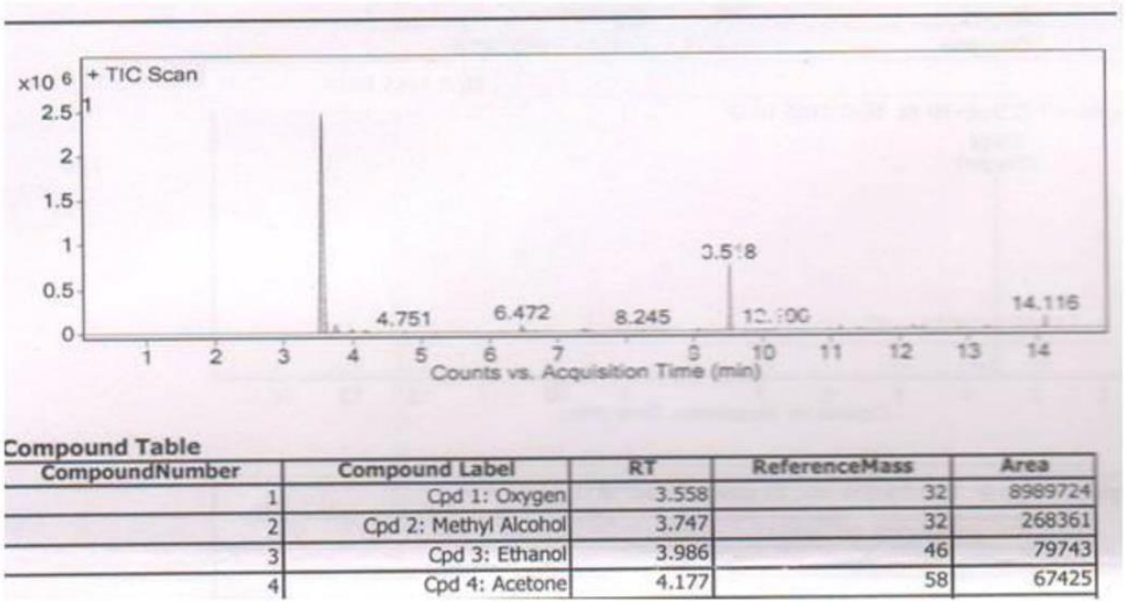


Fig. 3A: FID signals for methanol and ethanol and internal standard in case-2



Compound Table

CompoundNumber	Compound Label	RT	ReferenceMass	Area
1	Cpd 1: Oxygen	3.558	32	8989724
2	Cpd 2: Methyl Alcohol	3.747	32	268361
3	Cpd 3: Ethanol	3.986	46	79743
4	Cpd 4: Acetone	4.177	58	67425

Fig. 3B: Gas chromatogram (GC-HS-MS) with compounds list of exhibit of case -2

DISCUSSION

In case study 1 floor cleaners purchased from the local market were also analyzed by the instrument and results were compared with the gastric lavage and extract from the bottle. Presence of similar components in all samples suggest use of floor cleaner to commit the crime. Literature survey reveals that lethal ingestion of house hold cleaner can be fatal and characterization of biogenic volatile organic compounds emiting from cleaning products has been successfully detected by GC-MS in biological specimens as well as packaged containers[29,30,31]. In case study 2, nail polish removers of different brands were compared with extracts of viscera and blood of the victim. Presence of ethanol, acetone and methanol in exhibits as well as in the market formulations suggest use of nail paint remover to commit suicide. The use of volatiles compound in these two cases showed administration of mixtures containing volatile compounds in violence against women. Criminal use of chloroform and methanol is mentioned in the literature[32,33]. Comprehensive toxicological examination including instrumental analysis of viscera and body fluids gives a clear picture about the possibility of unknown compounds which may otherwise escape during routine screening with the toxicologist missing the target compound.

CONCLUSION

Crimes against women are commonly encountered in the Indian subcontinent where it is a societal problem. For a forensic toxicologist, detection of volatiles and associated constituents is difficult if samples are not adequately preserved .The cases examined indicates that HS-GC-MS is suitable for rapid qualitative analysis for unknown volatile components with miniscule sample preparation. This technique is extremely successful especially where a history of ingestion of household cleaning agents which are thermally sensitive volatile compounds are suspected. The development and application of techniques for headspace collection of volatiles in combination with GC-MS gives credibility to the chemical examination of challenging forensic exhibits. Our findings demonstrated that body tissues and human blood is a good source of volatile organic compounds (VOCs) and relevant target for toxicological screening of signature VOCs in forensic specimens specially when the cases are related to household chemical and cosmetics using hyphenated techniques (HS-GC-MS). This has provide an incredible opportunity for the detection of substance earlier believe to be challenging. There is further scope for investigation through spectroscopic techniques such as Gas chromatography - Infra red spectroscopy (GC-IR) depending upon the forensic science laboratory which has access to such alternative techniques. Quick and contamination free separation with low solvent consumption minimizes the exposure of toxicologist to hazardous chemicals and reduces the emission of such solvent to the environment.

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ETHICAL ISSUES

None

CONFLICTS OF INTEREST

There are no financial, or other, reasons that could lead to a conflict of interest.

AUTHOR CONTRIBUTIONS

PC: carried the literature review, instrumental analysis, analysed data and participated in drafting the manuscript; **KLV:** conceptualizing, designing, supervising and interpreting the data pertaining to this case report; **RC:** performed experiments, instrumental analysis and analysed data; **LTV:** performed experiments, instrumental analysis and analysed data.

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