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DEATHS FOLLOWING DROWNING IN SRI LANKA - A RETROSPECTIVE STUDY -

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ABSTRACT

Introduction: Deaths following drowning are a common occurrence in Sri Lanka. Individuals drown in different circumstances like suicides, accidents and homicides. A study of this nature would be useful for prevention of such incidences and as a baseline for future studies.

Objectives: With regard to victims of drowning to determine; the demographic profile, circumstances, autopsy findings and contributory factors for drowning.

Methodology: Information was extracted from records of 59 drowning cases in the years 2008-2017. Data were analysed using the statistical package SPSS Version 22.

Results: Majority of deaths (37.3%) were within the age of 11-30 years. Twenty-six-point five percent (26.5%) of accidental deaths were within the age group 11-20 years. The circumstances were accident (57.6%), suicide (22 %) and not known whether accident or suicide (20.3%). The common places of accidental drowning were sea (20%), Tank (20%) and canal (18 %.) The well was the most common place for suicides (54%). Majority of victims were unemployed (37%) and labourers (25%). Froth in the nostrils (54.2%), Emphysematous expanded lungs (63%), rib indentation on the lungs (61%) froth in the airways (61%) and pulmonary oedema (66%) were observations which were suggestive of drowning. Environmental factors (41%) and alcohol consumption (20%) are among the possible contributory factors.

Conclusion: Majority of the deaths are accidental. Environmental factors and alcohol consumption may play contributory roles. Awareness programmes targeting young adults will minimize accidental deaths.

INTRODUCTION

Drowning is the process of experiencing respiratory impairment from submersion/ immersion in liquid according to the WHO World Congress on Drowning. Death, morbidity and no morbidity following immersion are the common outcomes of drowning.[1] Deaths following drowning number around 372,000 per year worldwide and is considered a serious and neglected public health issue.[1] Drowning is one of the ten leading causes of death for people aged 1-24 years in every region of the world.[1] The low- and middle-income countries contribute to more than 90% of unintentional drowning deaths.[2] Moreover, globally more than half of the drowning deaths involve victims who are less than 25 years. No significant efforts have been taken to prevent drowning in comparison to the preventative mechanisms adopted for non-communicable diseases. Bodies found in water needs thorough forensic investigation to establish cause and manner of death.[3]

The Life Saving Association of Sri Lanka developed a report in collaboration with Life Saving Victoria and the World Health Organization, country office for Sri Lanka. (December 2014). According to the report Sri Lanka has one of the highest drowning rates internationally, ranking 12th highest in a comparison of 61 countries, and 10th highest when compared to 35 Low- and Middle-Income Countries (LMIC). On average, 855 people drown in Sri Lanka each year, a drowning rate of 4.4 deaths per 100,000 persons (from 2001, 2006 and in 2009).[4] Further the report revealed North Western (6.3%) and North Central (5.4%) provinces had a higher drowning death rate than the national average (4.4 per 100,000). Even in some of the provinces adjoining the ocean (Eastern and Northern), the commonest location of drowning was reportedly lakes and wells.[4,5] The ministry of disaster management had led a multidisciplinary team and was specifically interested in drowning prevention and water safety of Sri Lanka.[6]

The environmental factors such as rough sea, sudden rise of water levels, floods and water sources of unknown depths were some of the causes that contributed towards drowning in this study. The presence of alcohol in stomach contents may also have contributed in drowning deaths.

A study of this nature will highlight the significance of deaths related to drowning by mainly considering the demographic factors, circumstances and contributory factors. Maintaining a national data base, sensitizing authorities to the importance of preventive measures and encouraging future research on morbidity and deaths related to drowning are the expected outcomes of this study.

OBJECTIVES

With regard to victims of drowning to determine; the demographic profile, circumstances, autopsy findings and contributory factors for drowning.

MATERIALS AND METHODS

The 59 deaths, due to drowning which occurred in the period 2008-2017 confirmed as drowning by death investigation were included. Data were extracted from postmortem reports and analysed using the statistical package SPSS version 22. The drowning deaths involving unidentified individuals were excluded from the study. The majority were fresh bodies (n=39) with the rest with various time intervals of decomposition.

RESULTS

Majority of the drowning deaths have occurred in the age group between 11-20 years (18.6%), 21-30 years (18.6%) and 31-40 years (16.9%). It was rarely seen in the extremes of age; 1.7% in the age group less than 10 years and 1.7% in those between 81-90 years. The predominant gender was male (81.4%).

While the commonest circumstance was accident (57.6%) followed by suicide (22%). In 20.3% of cases the circumstance was unascertainable. There were no homicides.

When considering the age distribution in accidental deaths the majority were between 11-20 years. (26.5%), followed by (17.6%) between the ages of 21-30 years, (17.6%) between 31-40 years and (17.6%) between 51-60 years. The 41- 50 years age group represented 5.9%. The extremes of age groups such as less than 10 years were 2.9% and 61-70 years 11.8%.

Table 1: Occupation

Occupation	Number (%)
Unknown	13 (38)
Unemployed	11 (32)
Labourer	07 (21)
Army Soldier	01 (3)
Businessman	01 (3)
Clerk	01 (3)
Total	34 (100)

The table 1 shows the drowned individuals were mostly unemployed (32%) or labourers (21%). The documentation regarding (38.2%) of individuals was not available in the autopsy reports.

It was found to be difficult to extract the information from the reports regarding the capabilities to swim of most of the individuals in accidental drowning. Details regarding the diseased ability to swim were not documented in half of the drowned individuals (50%). The other important observation was 38.2% of the individuals who drowned can swim. The rest could not swim.

Table 2: Place of drowning in accidental deaths

Place of drowning	Number (%)
Sea	7 (20)
Tank	7 (20)
Canal	6 (18)
River	5 (15)
Well	3 (9)
Flooded area	2 (6)
Pit	1 (3)
Lagoon	1 (3)
Stream	1 (3)
Not known	1 (3)
Total	34 (100)

The sea (20%), tank (20%), canal (17%) and river (15%) were the common locations for accidental drowning (Table 2).

Majority (52.9%) of accidental drownings have occurred between 12- 6.00 pm. Twenty nine percent had occurred from 6 am to 12 noon while only 5.9% had occurred from 6.pm to 6 am. In 11.8% of cases the time was not known.

Table 3: Place of drowning in suicidal deaths

Place of Drowning	Number (%)
Well	7 (54)
Canal	3 (23)
Sea	2 (15)
River	1 (8)
Total	13 (100)

Majority of suicidal drowning has taken place in wells and canals (table 3). Majority of bodies recovered were fresh (n= 39, 66.1%).

The signs supportive of drowning during the external examination were white foamy froth or pinkish froth in the nostrils (n=32, 54.2%) and cadaveric spasm (n=1, 1.7%). No signs were present in 26 (44.1%) deaths.

Table 4: Features supportive of drowning during the internal examination (more than 01 sign may be present)

Feature	Number (%)
Pulmonary oedema	39 (66)
Emphysematous, expanded lungs	37 (63)
Rib indentation on the lungs	36 (61)
Froth presents in the airways	36(61)
Congestion	24 (41)
Foreign particles beyond secondary bronchi	18 (30)
Lungs covering the anterior border of the heart	15 (25)
Asphyxial features	07 (12)
No signs were present	05 (9)

Inference: Pulmonary oedema, emphysematous lungs, rib indentations and froth in airways are important features of drowning.

Table 5: Contributory factors for accidental drowning

Contributory factor	Number (%)
Environmental factors (rough sea, sudden rise of water level, floods etc.)	14 (41)
No reason identified	8 (23)
Alcohol consumption	7 (21)
Inability to swim	2 (6)
Natural disease	1 (3)
Neurological impairment	1 (3)
Psychiatric illness	1 (3)
Total	34 (100)

Environmental factors and alcohol consumption were the most common possible contributory factors. In a significant proportion of persons, no reasons were identified.

DISCUSSION

Sri Lanka which is an island has distinguished hydraulic civilization, famous for irrigation tanks, canals and rivers. People especially of small villages have access to natural water pools or irrigation tanks which they use for their daily needs including entertainment. Most people have their own well which may be protected or unprotected. In some of the villages people cross water canals on wooden blocks without adequate protection or use a wooden stage (*Paruwa*) for transport along waterways. Due to heavy rain in the central hill country water levels may suddenly rise in the lower regions without warning. Even though sea beaches have warning signs with graded risk, irrigation tanks do not have the same. Sometimes without knowing the actual depths children and adults drown being poor swimmers especially in irrigation tanks and sea. Life guards are available only in a few beaches. Once someone starts to drown, the outcome is often fatal. Unlike other injuries, survival is determined almost exclusively at the scene of the incident, and depends on two highly variable factors: how quickly the person is removed from the water, and how swiftly proper resuscitation is performed.[1]

The data based on surveillance of drowning deaths is minimal in Sri Lanka. The overwhelming majority of drownings happen in low and middle income countries where people have close daily contact with water for work, transport and agriculture.[1] The data collection in many low and middle income countries is limited, hampering the planning, implementation and monitoring of drowning prevention measures.[1] This study illustrates similar observations made by the WHO in Sri Lanka and other countries which exhibit similar environment. The affected individuals are mostly males and mostly come from the age group of adolescents and young adults as seen in other similar studies.[7,8] They tend to prefer bathing, swimming and travel in water such as sea, lake, river and other water sources.

The peer pressure may be so intense that groups of individuals seek to enter water for pleasure and fun related activities. Unforeseen natural calamities cause death due to drowning even in certain cases where the drowned individual can swim.[1,4] Sri Lanka is a culturally sensitive country with a male preponderance for water related activities. Female children are restricted and often supervised by elders. They are not left alone frequently to indulge in swimming or bathing in open water sources. In schools with swimming pools there is no gender bias but in other instances there may be. Boys and young males are not supervised stringently and they are free to go on trips with their friends and swim at any places. Lack of awareness sometimes makes them vulnerable to swim in dangerous locations.

Majority of cases are accidental drowning and most of them belong to the 11-20 years age group. Most of the accidental deaths have taken place in the sea, irrigation tanks or canals. These are the preferred places sought after by the youth for recreational swimming and pleasure.

In contrary to this a drowning related study done in an enlarged European union revealed the susceptibility of elders rather than the young adults.[9] Another study on drowning deaths in river was stressing the importance to identify the research gaps and rectify them timely.[10] Suicidal drowning was seen in 22 % of cases. Most of the individuals have chosen the well for this purpose. The easy access to this water source at the time of an emotional disturbance could be a plausible explanation. The prevention of suicides should be addressed as whole in the country and jumping into water is only one way of committing suicides in comparison to the other methods like hanging and ingestion of poison.[11] Identifying the trends in accidental and suicidal drowning deaths will help to take preventive measures in future.

If a careful analysis of the social background is given it was obvious that most of the individuals who got accidentally drowned were either labourers or unemployed with the available data. It is postulated that they may be using these water ways for their daily needs. They may be not in a position to frequent places which are safe and provided with life guards. This group of socially unnoticed individuals needs special attention. It is not quite obvious whether lack of literacy has any preponderance towards accidental drowning. However, if an individual is wealthy, he may avoid unsafe water sources.

Lunch and evening hours are considered to be more preferable for a water related activity resulting in more accidental deaths. Similar fatal drowning incidents were mostly observed between 12.00 and 2 pm in South Africa.[12]

The information regarding the ability to swim of the individuals were not available in most occasions. Moreover 38% were able to swim in accidental deaths. The lack of information in 50% of cases emphasizes the poor recording regarding the background of the drowned victims and was a limitation in relation to future prevention measures. The other striking finding is the capacity of 38% of individuals who can swim. Sometimes the ability to swim may encourage risky behaviour and thus may result in drowning. In a country with adequate literacy, children of school going years must be trained in swimming as a life skill to avoid accidental deaths due to drowning. Sri Lanka surrounded in all fronts by sea with the interior containing lakes, water reservoirs and manmade wells makes it more prone to an individual to die from drowning.

Fresh body was found in most occasions. The immediate recovery of bodies following drowning deaths is important since decomposition changes will interfere with the interpretation of autopsy findings. Since the drowning is a diagnosis of exclusion of other causes, the recovery of the body at the earliest opportunity will minimize hidden homicides.

1/3rd of bodies were decomposing at the time of autopsy indicating delayed recovery of the body from water ways. Deaths taking place in sea and large water reservoirs often make difficulties for the rescuers to find the missing persons and thus results in long delays and decomposition.

The signs including the characteristic froth were not observed during the external examination in 44.1% of cases. This could be due to the presence of decomposition or dry drowning. Nearly 60% of victims had froth in the air way, rib indentation, expanded lungs and pulmonary oedema as the most observed internal features indicating wet drowning among the victims. This study revealed that the autopsy findings both external and internal contributed to arrive at the cause of death and all the bodies may not show the features to support drowning.[13] The diatoms test was used in the past to diagnose drowning but it is not done in all forensic centers now. A study done in Sri Lanka revealed the prevalence of different types of diatoms found in autopsy samples.[14] This study sample did not involve travelers or tourists from other countries.

However, the overall safety measures to prevent drowning deaths will certainly benefit the tourists as well. A study published in the journal of travel medicine highlights some of the prevention measures.[15] Further there are limited research articles available regarding the epidemiology of drowning containing quantitative data in low- and middle-income countries.[16] Hence, making space for more research work towards drowning.

The high altitude of sea waves, sudden rise of water level, rough sea and floods are some of the important and dangerous environmental factors that may have contributed in accidental deaths in this study. Deaths have occurred even with individuals who know swimming. The lack of environmental signs indicating dangerous areas may prone entry into harmful water sources. Alcohol consumption was suspected in seven individuals following accidental deaths, with the available history and presence of alcohol in the stomach. When analyzing the background of an accidental drowning death, the in-depth analysis of contributory factors is important to prevent future deaths. Three were miscellaneous reasons like psychiatric illness; neurological disability etc. identified in this study but the exact contribution is difficult to prove. A study done in Sweden explains the role of alcohol consumption in drowning deaths involving children. The risk factors included: coming from a single parent-headed family, alcohol use by older victims and a lack of ability to swim.[17] Another study done in United Kingdom involving children emphasizes the role of adult supervision in preventing drowning related deaths.[18]

It is important to strengthen the role of a national governing entity to finalize the national action plan and establish a national governing entity for drowning prevention and water safety.[6] "The National Advisory Committee will develop a proposal on risk profile, customize beach/pool operational guidelines, improve swim for safety curriculum, identify and promote safe bathing and swimming zones, and develop a surveillance system to be framed into the National Action Plan of Sri Lanka". The role of the national governing entity would be to implement the national action plan and monitor progress, assigning steering and technical committees to decentralize the solutions[6].

The data collection in Sri Lanka is limited being a serious debacle in planning, implementing and monitoring of drowning prevention measures. Further the near drowning cases also may go unnoticed which often results in life long impairment of functions and heavily dependent on healthcare facilities.[1] It is imperative to carry out an island wide research analyzing all the drowning deaths with possible contributory factors. As a way forward to minimize drowning deaths preventive measures should be initiated starting from the schools. The citizens of all ages must be educated of the dangers of swimming in unknown and dangerous water resources. There are individuals who use water sources to commit suicide by drowning. A Sri Lankan study found 3% of the suicides due to drowning.[19] In the global scenario drowning is among the 10 leading causes of death of children and young adults in every region of the world and males with a higher probability in comparison to females.[1]

A simple study of this nature will narrow down the important demographic factors, circumstances and other contributory factors of drowning and will strengthen further research on drowning.

The policy frame work is active and well designed to prevent drowning deaths in Sri Lanka. A suitable data base covering the whole island related to drowning deaths would be an added advantage for further researches.

CONCLUSIONS

Majority of the deaths were accidental. The common places of drowning in accidental deaths were the sea and irrigation tank.

RECOMMENDATIONS

1. A national data surveillance on drowning deaths by an established authority
2. Establish lifesaving associations at town and village levels
3. Include mandatory swimming lessons in school curriculum
4. Provide national funding for research targeting morbidity and mortality due to drowning
5. Establish a government mechanism to collect data on drowning related incidents, water safety and training to prevent drowning related deaths
6. Develop an action plan for water safety and prevention of drowning deaths.
7. A prospective study regarding drowning deaths involving all provinces should be initiated.
8. Governments and other non-governmental organizations must prioritize prevention of drowning deaths and integrate with other public health issues.

LIMITATIONS OF THE STUDY

The sample size was small and reflects the autopsy experience of the authors. As this is a retrospective study, the recording of autopsy findings may show minor subjective variations but may not influence the cause of death. The decomposed bodies in comparison to fresh bodies may pose difficulties in autopsy findings but have not compromised the cause of death.

However, the trends observed were similar to other parts of the world and corresponds to the previous studies done in Sri Lanka. Further it is presumed the geographical variations regarding water sources are minimal in low altitude areas.

ETHICAL ISSUES

The data was generated as a collective one and individual identity is not available. The study adhered to the ethical guideline of the medico-legal institution and the health facility. This was a retrospective study.

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHOR CONTRIBUTIONS

PP: Conception and design of the work, identifying the key data to be analyzed, interpretation of data, initial drafting and addressing amendments from reviewers and editors, and final approval; **WNSP:** Conception and design of the work, identifying the key data to be analyzed, interpretation of data, amendments to the initial draft by first author, and final approval; **SL:** Conception of the work, identifying the key data to be analyzed, interpretation of data, and final approval; **DCP:** Conception of the work, identifying the key data to be analyzed, interpretation of data, and final approval; **TAAWS:** Conception of the work, analysis of data and tabulation, and final approval; **MKJKK:** Conception of the work, analysis of data and tabulation, and final approval.

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MANAGEMENT OF THE DEAD IN DISASTERS: KNOWLEDGE, ATTITUDES AND SELF-REPORTED PRACTICES AMONGS A GROUP OF ARMY SOLDIERS IN SRI LANKA

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ABSTRACT

Introduction: Improper management of the dead in disasters can hinder the identification, leads to loss of important forensic evidence and affects the dignity of the dead. Army soldiers play a vital role in dead body management in disasters.

Objective: To describe the knowledge, attitudes and self-reported practices on management of the dead in disasters among a group of army soldiers in Galle district, Sri Lanka.

Materials and Methods: This descriptive cross-sectional study was conducted using a self-administered questionnaire. Based on the percentage of correct responses, participants were classified into three groups denoting their overall knowledge using pre-determined cut-off values (>70% - "good", 50-70% - "moderate", <50% - "poor" level of knowledge).

Results: The study population was 188 army soldiers (n=188). A majority (61.2%, n=115) had a moderate level and 32.4% (n=61) had a good level of overall knowledge. Knowledge regarding wearing face masks by dead body recovery teams was poor in 92%, while knowledge in spraying disinfectants to dead bodies was poor in 69.1%. Respectively 21.8% and 52.1% believed that funeral rites are not important and dead bodies of foreign nationals should be treated better than locals. A majority (59%) had reported that they used gloves and boots in dead body recovery process.

Conclusions: Even though a majority had either moderate or good level of overall knowledge, deficiencies of knowledge in certain aspects were evident. A majority had more favourable attitudes and there is a space for improvement in certain practices of dead body management.

INTRODUCTION

The way that human remains are managed in a disaster situation has a significant impact on the well-being of survivors. Improper management of the dead in such situations can lead to loss of valuable forensic evidence, delay the identification of the deceased, and preclude dignified burial.[1] Thus, inappropriate management of the dead has social, psychological, economic and legal consequences on the survivors, which in turn exacerbates the damage caused by the disaster itself.[1]

Experience from natural disasters such as the 2004 Indian Ocean Tsunami and the 2013 Typhoon Haiyan in the Philippines has shown that the 'first responders' play an important role in managing the dead in disasters.[2]

These first responders can do a lot to give the best possible opportunity to investigators to identify the remains of those deceased and clarify the fate of missing people.[3] In other words, the early work of first responders in a disaster determines the success of much of the work done by medico-legal experts later. Consequently it has a significant influence on the dignity of the deceased and long-term psychological, social, economic and legal impacts on survivors.

Among the stakeholders involved in a disaster response, the army plays a key role. Their role in disaster response has increased in the recent past due to increased incidence and magnitude of natural disasters and increased interest of military institutions in disaster response.[4] In the Sri Lankan setting army soldiers play a vital role in the process of dead body management in disasters. They act as either responsible persons or supporting persons in almost all activities in dead body management in disasters.[1] The importance of their role was evident during recovery of human remains in recent disaster situations in the country, such as, the collapse of the garbage dump at Meethotamulla, the landslides at Meeriyabedda and Aranayake.

The objective of this study was to assess the level of knowledge of management of the dead in disasters among army soldiers who are first responders in disasters.

MATERIALS AND METHODS

This descriptive cross-sectional study was carried out in two selected army camps in the Galle district, Sri Lanka in 2017. The study population included all army soldiers working in the two army camps during the days of data collection. Informed consent was obtained prior to the data collection. Authority was obtained from the Ministry of Defence, Sri Lanka and the respective officials of the Sri Lanka Army. Ethical approval was granted by the Ethics Review Committee of the National Hospital of Sri Lanka. Since data was collected from the entire population, sample size calculation and sampling technique were not applicable.

The data collection instrument was a self-administered questionnaire in which the contents were in accordance with the objectives of the study. The questionnaire was pre-tested in a small sample of eight army soldiers in Colombo who volunteered to participate in the pre-test. Information for the participants explaining the purpose of the study, ensuring anonymity and confidentiality was included at the beginning of each questionnaire. The face validity of the questionnaire was done and initially it was prepared in English. Then it was translated into Sinhala and Tamil which are the national languages of Sri Lanka. The questionnaire consisted of close ended type questions with four sections. The first section consisted of basic socio-demographic data of the participants. The second section consisted of thirty-three true /false type questions regarding the knowledge on management of the dead in disasters. Attitudes on management of dead in disasters were included in the third section. In the fourth section questions on self-reported practices during management of the dead in disasters were asked.

The army camps were visited by the principal investigator at a pre-arranged time. The questionnaires were administered while the soldiers were physically present in camps and they were requested not to communicate with each other during answering.

Statistical analysis of data was performed using the statistical package for social science (SPSS), version 21. Knowledge on management of the dead in disasters was assessed by scoring the thirty-three items of the second section of the questionnaire. Each correct response was awarded one mark. Thus, the total score ranged from zero to 33 which was converted into a percentage.

A score of > 70% was categorized as having a "good" level, a score of < 50% was categorized as having a "poor" level, and a score of 50 - 70% was considered as having a "moderate" level of knowledge on management of the dead in disasters. Socio demographic characteristics, individual items assessing the knowledge, attitudes and practices on dead body management in disasters were described using frequency distributions. Overall level of knowledge was cross analyzed with service duration and highest educational level to identify possible associations using chi square test of independence. A probability value of less than 0.05 was considered as significant.

RESULTS

The study sample consisted of 188 male army soldiers. A majority (51.6%, n= 97) were in 31-40 years of age whereas 31.4 % (n=59) of the study sample was 30 years old or below. 43.6% (n=82) had passed the General Certificate of Education Ordinary Level (GCE O/L) examination. Majority (64.9%, n=122) of the participants had a service of 10 years or more in Army.

The participants were asked different aspects of the management of the dead in disasters. Out of the total, 67.6% have answered correctly to the false statement "Dead body recovery is the most urgent task in a disaster". While 81.9% knew that establishment of a scene management team is necessary, 87.2% and 92% respectively were aware that a body receiving point has to be determined and a body recovery register should be maintained before dispatching the bodies from the scene.

The participants were questioned regarding numbering of the bodies and 93.6% knew that a unique reference number should be given to each body and 87.2% said that the number tags should be attached to the wrist or ankle of a complete body.

Majority (92%) agreed that the bodies should be released after confirming the identification and 51.6% responded correctly to the false statements that every attempt shoud be made to identify the bodies and all attached personnel belongings should be removed (54.8%) at the scene itself. Only 36.2% of the participants responded correctly to the false statement that obtaining a single photograph of a body is adequate.

Regarding fragmented bodies, 45.7% stated that every body part should be considered as a separate individual and 52.7% thought that all fragmented pieces in a particular area could be collected into a single container. While 66.5% have responded correctly as false to the statement that the recovery team should attempt to match body parts at the scene, 52.1% have responded correctly to the false statement that the personal belongings separated from the body belongs to the closest body.

Majority (77.1%) stated correctly that the bodies should be placed in separate body bags with personal belongings, sealed (74.5%), and that plastic sheets, bed sheets or other available material may be used as an alternative, if body bags were not available (86.7%). Only 34% knew that ambulances should not be used to transport the bodies.

Out of the total, 76.6% were aware that refrigeration of dead bodies between 2 ^{0}C and 4 ^{0}C is the best option for storage of bodies, while 47.3% were aware that the temporary burial is also a good option, when no other method is available. While 71.8% knew that laying bodies on top of each other, with an intervening layer of soil in temporal burial is wrong, and only 37.2% knew that using iced water for storage of bodies is not useful.

92% of the participants in the study knew correctly, that handling dead bodies carries only a small risk of infection through contact with blood and faeces. But only a few (8%) knew that wearing a face mask and spraying disinfectants (30.9%) to dead bodies is not essential during body recovery.

Several administrative issues which are commonly faced by the first responders at the scene of mass disasters were included into the questionnaire. Of the participants, 91% were aware that legal problems that arise to the relatives as a consequence of mismanagement of the dead. However, 52.1% and 44.7% have given a correct response to the false statements `politicians can participate` and `direct communication with outsiders/media should be done` respectively. Only 51.1% knew that journalists should not be allowed on the scene immediately after the disaster.

Table 1: Items in the questionnaire for which the participants' knowledge was poor (n=188)

Item	Percentage of participants who responded correctly
Wearing face masks is essential for teams involved in dead body recovery **(False)**	08.0
Spraying disinfectants to dead bodies is essential **(False)**	30.9
Ambulences should not be used to transport the dead bodies **(True)**	34.0
Obtaining a single photograph in relation to an individual body is adequate **(False)**	36.2
Ice (frozen water) should be used for storage of dead bodies **(False)**	37.2
Direct communication with outsiders/media and revealing information should be done by all the team members **(False)**	44.7
Every body part that is completely separated should be treated as a separate individual **(False)**	45.7
Temporary burial is a good option for immediate storage where no other method is available **(True)**	47.3

The majority of the participants (61.2%, n=115) were found to have a "moderate" level of overall knowledge on management of the dead in disasters whereas 32.4% (n=61) were found to have a "good" level of overall knowledge. Level of education was significantly associated with the overall knowledge on management of the dead in disasters (Chi-square 6.023, df=2, p< .05). There was not enough evidence to suggest a significant association between the service duration in the army with the overall knowledge (Chi–square 1.142, df=2, p= .565).

Attitudes of the study population were assessed using ten attitudinal statements (**Table 2**).

Table 2: Attitudes on management of the dead in disasters (n=188)

Statement	Agree	Disagree	Not answered
Dead bodies of children should not be given priority	10.1	89.4	0.5
There is no need to respect dead bodies as they are dead.	12.8	86.7	0.5
Identification of dead individuals is not important in disasters as there are large numbers of casualties.	19.7	79.3	1.1
Funeral rites are not important.	21.8	76.1	1.1
Mistaken identity is not a big issue to be worried.	23.4	75.0	1.6
Pre planning for disasters is a waste of money and time as disasters are unpredictable.	25.5	72.3	2.1
Necessity of members of the affected families to know the fate of their loved ones should not be a priority.	27.7	71.3	1.1
Following guidelines is impractical.	33.0	65.4	1.6
Unidentified bodies should be buried in common graves to save time and money.	48.9	50.0	1.1
Management of bodies of foreign nationals should be treated better than the locals.	52.1	47.3	0.5

Majority of the participants (n=130, 69.1%) had experience in dead body management as army soldiers. The practices they followed in the management of the dead in disasters as seen in Table 3.

Table 3: Practices in the management of the dead in disasters (n=130)

Practice	Percentage
Burial of a large number of dead bodies in a common grave (No)	35.6
Matching of body parts with incomplete bodies at the disaster scene (No)	41.5
Establishment of a scene management team immediately after a disaster (Yes)	44.7
Assigning a unique reference number to each body (Yes)	51.6
Tagging of each body with a unique reference number (Yes)	51.6
Sealing of body bags after placing bodies (Yes)	53.2
Obtaining photographs of the disaster scene and dead bodies (Yes)	53.7
Placing of each dead body in a separate body bag (Yes)	54.8
Use of ambulances to transport dead bodies (No)	58.0
Use of gloves and boots in dead body recovery process (Yes)	59.0

DISCUSSION

The level of overall knowledge of study population in the study is satisfactory with the majority (93.6%) having either moderate or good level of overall knowledge on management of the dead in disasters. Yet considerable gaps in important aspects of dead body management were evident. In particular, knowledge on wearing face masks by personnel involved in dead body recovery, taking photographs, spraying disinfectants to dead bodies and use of ambulances to transport the dead was poor.

Though a majority (92%) knew that individuals handling dead bodies have a small risk of infections via contact with blood and faeces, only a minority (8%) knew that wearing face masks is not essential for teams involved in dead body recovery. Facemasks do not filter or provide protection for a considerable period of time and they can slow down some tasks of the users such as moving, storing, and preparing corpses. Moreover, the danger of contamination via respiratory tract is minimal since there is no respiratory function in dead bodies .[5]

Guidelines state that the dead bodies should not be transported in ambulances and vehicles used for transportation of consumable items.[5] In the present study, only 34% of the participants were aware of it. Assigning a unique reference number to each body or body part is a must[1] to avoid loss of bodies, to ensure traceability and correct documentation, and to enhance identification of the deceased.[2] Interestingly a majority (93.6%) of respondents in the study were aware of it.

Although there was not enough evidence to suggest a significant association between service duration of soldiers with overall knowledge on management of the dead in disasters (Chi–square 1.142, df=2, p= .565), level of education was significantly associated with overall knowledge (Chi-square 6.023, df=2, p< .05). In a study conducted on mass fatality preparedness among coroners / medical examiners in United States, conducting training programmes had a significant association with preparedness measures.[6]

This study showed that a majority of participants had more favourable attitudes in many aspects of management of the dead in disasters although there were some negative attitudes to a certain extent. In a study conducted among health care workers, most of the participants had highly positive attitudes towards mass fatality management following disasters.[7]

Usually the bereaved want to see the corpse to say “goodbye” and to conduct ceremonious funerals.[8] Only 21.8% of participants in this study believed that funeral rites are not important in management of dead in disasters. Similarly, an Indonesian study stated, “Participants identified that right to mourn and the right to be treated according to one’s religion even after death”.[9]

A noteworthy finding of this study is the attitude of more than half (52.1%) of the study subjects that management of bodies of foreign nationals should be treated better than the locals. Guidelines laid by College of Forensic Pathologists of Sri Lanka clearly state that, “Every victim, foreign or Sri Lankan, would be treated equally”.[1] It is well documented in the field manual for first responders that; “Pressure to prioritize the finding of foreign nationals must not be allowed to distort the priorities of a systematic local approach to identifying all the dead”.[2]

Regarding self-reported practices pertaining to management of the dead in disasters, more than half (54.8%, n=103) of the study population reported that they have placed each dead body in a separate body bag whereas 51.6% (n=97) of participants have stated that they have assigned and tagged a Unique Reference Number to each dead body. But according to Perera and Briggs, following the Indian Ocean Tsunami in 2004, tagging of dead bodies with ‘permanent identification codes’ was not done before disposing them.[10]

To our knowledge, this is the first study conducted in Sri Lanka to describe the knowledge, attitudes and practices on management of the dead in disasters among first responders. It could be considered as a major strength of this study and the findings will aid to bridge the gaps in the subject. One limitation of this study is that it was confined to male soldiers. Secondly, as data was collected using a self – administered questionnaire, there's a possibility that participants may have provided socially desirable responses, especially with regard to practices rather than the actual practices that they had engaged. There could be an element of recall bias with regard to practices since the data asked about practices were not confined to the recent past.

Even though a majority of army soldiers had either "moderate" or "good" level of overall knowledge on management of the dead in disasters, deficiencies of knowledge in certain aspects were evident. A majority of participants had more favourable attitudes in many aspects of management of the dead in disasters although there were some negative attitudes to a certain extent. There is a space for improvement in certain practices of dead body management.

This study recommends improving the training opportunities for army soldiers to enhance their knowledge and experience on management of the dead in disasters. More consideration should be given to offer specific instructions on different aspects of dead body management during training programmes.

ETHICAL ISSUES

The Ethical Review Committee of the National Hospital of Sri Lanka has granted approval for this study.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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AUTHOR CONTRIBUTIONS

UGGC: Conception and design of the work, acquisition, analysis and interpretation of data, drafting the work and critical revision, and final approval; **JW:** Conception and design of the work, acquisition, analysis and interpretation of data, drafting the work and critical revision, and final approval.

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RESEARCH ARTICLE

DELIBERATE SELF-HARM AMONG PATIENTS PRESENTING TO TEACHING HOSPITAL – KARAPITIYA, SRI LANKA
- A RETROSPECTIVE, DESCRIPTIVE STUDY -

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ABSTRACT

Introduction: Deliberate self-harm is defined as an injury inflicted on oneself without suicidal intent. Relatively few studies have been carried out in Sri Lanka on this aspect; therefore, reliable statistics are lacking.

Objective: To identify epidemiological and socio-economic factors and medico-legal aspects of injuries of due to deliberate self-harm in patients presenting to the Teaching hospital, Karapitiya.

Materials and Methods: All medicolegal records of patients examined by the authors with deliberate self-harm admitted to the Teaching hospital, Karapitiya from 1st of January 2010 to 31st of December 2014, were retrospectively analyzed.

Results: There were 47 patients. Eighty two percent were male. Majority (60%) were between 16 – 25 years. Sixty-one percent of them were married and 51% were unemployed. Only 12% had studied beyond G.C.E. Ordinary level. Most cases were reported during the period April to June. Twenty-two (46%) males had consumed alcohol at the time of the incident. Sixty-four percent had committed the act to gain sympathy or recognition. Superficial cuts and scratches were the most common type of injury (81%). The non-dominant upper extremities (75%) were the most common sites of injury. The commonest method used by males was cutting with sharp instruments whereas for females, it was pricking with needles and pins. Eighty-three percent had non grievous injuries. Sparing of clothes were present in 94%. Twenty-eight percent of patients had a history of similar previous attempts.

Conclusions: Injuries due to deliberate self-harm is a considerable public health problem which can cause significant harm especially among young males. Low level of education, unemployment and substance abuse were among the associated risk factors identified in this study. Young males were the most vulnerable group and they should be targeted when considering preventive measures.

INTRODUCTION

The Penal Code of Sri Lanka defines an "injury" as any harm, whatever illegally caused to any person in body, mind, reputation or property.[1] According to the World Health Organization, an injury is the physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy that exceed the threshold of physiological tolerance.[2]

Injuries can be categorized in a number of ways. By considering intention, injuries can be broadly divided as unintentional (accidental) and intentional (deliberate) injuries.[2,3] Unintentional injuries can be further divided based on causal mechanism and the place of injury whereas intentional injuries can be divided broadly in to the categories of self-inflicted injuries, interpersonal violence and collective violence.[2,3]

Causing self-harm is a practice dating back as far as the second century AD. This was known to occur among the members of the Roman army to avoid service in critical situations.[4] Self-inflicted injuries refer to a broad class of behaviours in which an individual directly and deliberately causes harm to herself or himself.[5]

Self-inflicted injuries can be divided in to two main categories; deliberate self-harm and attempted suicides. Deliberate self-harm is defined as an injury inflicted on oneself without suicidal intent, whereas attempted suicide is defined as a potentially self-injurious behavior associated with at least some intent to die.[3,4,5]

Self-inflicted injuries represent a serious public health issue. According to the literature, there is a significant rise in the reported self-inflicted injury incidences around the world.[6,7,8,9] Relatively few studies have been carried out in Sri Lanka in this aspect. Therefore, reliable statistics are lacking. Lack of epidemiological and medico-legal data on self-inflicted injuries has impeded the development and implementation of preventive and health promotive measures among the general public. This paper attempts to provide a descriptive overview of injuries due to deliberate self-harm and their medico-legal and epidemiological implications.

OBJECTIVES

To identify epidemiological and socio-economic factors and medico-legal aspects of injuries of due to deliberate self-harm in patients presenting to the Teaching hospital, Karapitiya.

MATERIALS AND METHODS

All patients presenting with deliberate self-harm to the Teaching Hospital, Karapitiya from 1st of January 2010 to 31st of December 2014, examined by the authors were considered. Information was gathered from the medico-legal examination forms (MLEF), bed head tickets and other relevant medical reports. The medico-legal records of 47 cases were evaluated. All attempted suicides were excluded. A pre-coded data collection form was developed and the routine data were analyzed to document epidemiological and socio-economic data and to describe the medico-legal aspects of injuries, by using Microsoft Excel and SPSS software.

RESULTS

Of 3478 medico-legal referrals examined by the authors 56 (1.5%) had self-inflicted injuries. Of those with self-inflicted injuries, 47 (1.3%) were due to deliberate self-harm and the remaining 09 (0.2%) were due to attempted suicides. The attempted suicide cases were excluded from the study. Out of the patients presenting with deliberate self-harm, 39 (82%) were male and 08 (18%) were female. Majority (60%) were in the age range of 16 – 25 years with the highest incidence for both genders being in the 21 – 25 age group **(Table 01)**. The youngest victim was a 14-year-old school boy and the eldest victim was a 43-year-old carpenter.

Table 1: Distribution based on age and sex

Age (years)	%	Male	Female
10 - 15	02	01	00
16 - 20	21	07	03
21 - 25	39	14	04
26 - 30	26	11	01
31 - 35	04	02	00
36 - 40	04	02	00
41 - 45	04	02	00

Out of the 39 males, 15 (38%) were unmarried and 24 (62%) were married. Out of the eight females, three (38%) were unmarried and five (62%) were married. Occupational status of victims showed that 51% were unemployed and 43% were working as unskilled (28%) or semiskilled (15%) labourers. Only 06% were skilled workers and none were professionals in the sample. When considering the level of education, only 12% had studied beyond ordinary level. None of them were degree holders. Most number of cases were reported during the period of April to June (47%) followed by October to December (27%) and January to March (14%). Lowest number of cases were reported during the July to September period (10%). Out of the males, 46% had consumed alcohol at the time of the incident followed by Marijuana (Ganja) (12%), and other substances of abuse (04%), whereas none of the females were found to have consumed any substance of abuse. Sixty-four percent (64%) had committed the act to gain sympathy or recognition. Psychiatric disorders were identified in 8% of cases after referrals **(Table 2)**.

Table 2: The identified reason

Identified reason	%	Male	Female
To obtain sympathy/ pity/attention	66	23	08
To gain recognition or admiration	06	03	00
Evasion of military services	13	06	00
Simulation of a crime / Fabricated injury	08	04	00
Psychiatric disorder	08	04	00

Superficial cuts and scratches were the common injury types (81%) **(Table 3)**.

Table 3: Type of injuries

Type of injury	%	Male	Female
Superficial cuts	38	17	01
Scratches	43	14	06
Bruises	14	06	01
Deep cuts	04	02	00
Fractures	00	00	00

Upper extremities (75%) including forearms, wrists, and arms were the most commonly affected sites of injury **(Table 4)**.

Table 4: Site of injuries

Site	%	Male	Female
Head	06	03	00
Face	00	00	00
Upper limb	75	28	07
Lower limb	06	02	01
Trunk	13	06	00

Majority of the male patients (n=31) had more than one injury whereas, majority of female patients (n=06) had only one injury. None of the females had more than 02 injuries whereas 04 males had more than five injuries. All female patients had characteristic features of injuries caused by deliberate self-harm **(Table 5)**.

Table 5: Characteristic features

Characteristic feature	%	Male	Female
Injuries present on the non-dominant hand	89	34	08
Multiple, parallel and superficial injuries	82	31	08
Sparing of clothes	94	36	08
Excluding vital sites	89	34	08

Twenty-eight percent (28%) of patients had a history of similar previous attempts and out of that 11 were males and 02 were females. The commonest method used for self-harm by males was cutting with sharp instruments (n=17) and hitting against glass windows and doors (n = 11). For females the commonest method was pricking with needles and pins (n = 5) **(Table 6)**.

Table 6: Method used

Method used	%	Male	Female
Cutting (blade, knife, broken bottle)	40	17	02
Hit against glass doors or windows	23	11	00
Pricking with needles and pins	10	00	05
Hitting with clubs	11	05	00
Hit against a wall	15	06	01

Eighty-three percent (83%) had non grievous injuries and none had injuries which were fatal in the ordinary course of nature. All females had only non-grievous injuries. Fifteen percent of males (n=6) had grievous injuries and 5% (n=2) had injuries which were endangering life.

DISCUSSION

Deliberate self-harm or the non-suicidal self-injury is most commonly described as deliberate, direct destruction or alteration of body tissue without conscious suicidal intent.[10,11] Prevalence of deliberate self-harm differs from country to country.[6,7,8,9] In Germany, the prevalence is reported to be around 0.6% to 0.8%[4] where as in Teheran, Iran it was around 12.6%.[5] Higher prevalence rates were reported with college students (38%)[11,12], incarcerated adolescents (10.4%)[13], and adolescent psychiatric in-patients (60%-80%).[14] According to one study done at the National Hospital of Sri Lanka, the prevalence was 1.4%. A similar prevalence rate of 1.3% was observed in this study.

Many authors have reported a higher prevalence of self-injurious behaviors among female than male. According to a Swedish study, the prevalence among female was 1.4% whereas among male it was 0.7%.[6] According to another study, of the patients presenting with deliberate self-harm, 70% were female.[16] In another study conducted at Contra Costa county, 60.3% of the patients presenting with self-injuries were female.[17] Some studies suggest otherwise. According to one study conducted in Minnesota, prevalence among males was 72%.[18] In this study, 82% of the patients who presented with self-injurious behaviour were male. The low level of prevalence among females could be due to multiple reasons. Frequently, these female patients would present themselves to their family physicians for treatment, therefore the number of reported cases could be low. On the other hand, some of these self-inflicted injuries can be mistaken as accidental injuries. If the attending doctor is not careful enough in history taking and examination, some of these injuries could easily get misdiagnosed as accidental injuries, especially if the history given by the patient is intentionally fabricated. The male predominance may be attributable to their active participation in risk taking behaviours and their frequent involvement in substance abuse.

A significant prevalence was noted among adolescents in many studies. According to a study conducted in Canada, the highest rate for both male and female was seen in the 15 to 19 age group.[19] In another study conducted in Teheran, Iran, the mean age of male self-injured patients was 23.2 ± 10.7 years and the mean age of the female self-injured patients was 29.8 ± 9.2 years. According to another study, the highest prevalence was noted among 15 to 20 age group.[16] In a study conducted at Minnesota, the highest prevalence was among the age group of 15 to 18 followed by 10 to 14.[18] In another study conducted among patients hospitalized with self-inflicted injuries at Contra Costa County, 26.3% of patients were from the 15-24-year age group.[17]

In this study, for both genders, the highest percentage of cases were reported from the age group of 21 to 25 (39%) followed by the age group of 16 to 20 (21%). These findings are similar to the findings of other studies. WHO defines 'Adolescents' as individuals in the 10-19 years' age group while 'Young People' covers the age range 10-24 years.[2] The high prevalence of self-injurious behaviour among the adolescents and young adults is a known phenomenon.[16,17,18,19] In this study, 23% of the patients were from 10-20 age group and 62% from the age group of 10-25 age group. This further supports the similar prevalence rates of other studies.

Marital status is another important factor in the analysis of deliberate self-harm patients. The literature on this aspect is very limited. According to one study conducted in Teheran, Iran, out of the patients presenting with self-injuries, 58% were unmarried.[5] However, in this study, 62% of the patients presenting with deliberate self-harm were married. Similar percentages were observed for both the male and the female patients.

High rates among those who are married could be related to marital problems though further study in this area is needed for valid conclusions.

The motivations for self-injury can be exceedingly diverse and multifactorial. The identified reasons for such behavior can be broadly divided in to three categories; psychological, judicial and material.[4] The described reasons under psychological category include, to obtain sympathy, to gain recognition or admiration, for pleasure and as a manifestation of mental disorder or disease. Under judicial category, simulation of a crime, defamation and defense against reproach (to justify illicit absences) are the leading causes. Insurance fraud and evasion of military service comes under the material category.[4] In this study, all three categories of psychological, judicial and material causes were observed as the given reasons among the patients. According to available literature, simulation of a crime is one of the commonest motives to cause self-harm.[4] In a study done in Teheran, Iran, underlying motive was simulation of a crime in 71% of the patients presented with self-injury.[4] Simulation of an alleged assault was the most common cause of referral for men, whereas for females it was fictitious sexual offence.[4] However, in this study, the identified reason for all the female patients (100%) was "to obtain sympathy or attention". This was the most common reason among males as well (59%). It is a known fact that some individuals hurt themselves in order to relieve negative emotional states.[20] The individuals who lack emotional stability are therefore at increased risk of self-harming behaviors. According to literature, self-harm for the purpose of insurance fraud is again a common situation.

In one study, the reason for self-harm was insurance fraud among 27% of the patients presented with self-harm.[4] However, in this study, none of the patients have given insurance fraud as the motive behind their act. In comparison, evasion of military services was a significant reason among the males (13%). Presence of a psychiatric disorder is a well-known risk factor for causing self-harm. In one study, 30.9% of the patients were found to have some form of mental disorder.[21] However, in this study, only 8% of the patients had a history of psychiatric illness. The low percentages could easily be due to lack of proper psychiatric assessment among these admitted patients at the hospital level.

Level of education, employment states and the socio-economic states are all important aspects to consider among the deliberate self-harm patients. Self-injurious behaviour is known to occur more frequently among those who are belonging to lower socio-economic states with low level of education and unemployment.[4,19,21] According to one study, 56% of the population presented with self-injuries were unemployed.[4] In the same study, 40.7% of the population only studied up to elementary level.[4] In another study, 72.1% had only primary or no formal education and most of them (89.7%) were unemployed.[21]

Similar findings were observed in this study. Fifty-one percent of the study population were unemployed and only 12% had studied beyond ordinary level.

Several studies have reported seasonal trends associated with deliberate self-harm. According to available literature, rates are higher in late spring (May) or early summer (June) and lower from November to January.[19,22,23,24] In this study, the highest number of cases were reported during the period of April to June (47%) followed by the period of October to December (21%). The societal and cultural factors may be responsible for some of the temporal variations observed in this study. As the April and December are widely recognized as festive months with lot of cultural significance, these times of the year sometimes can be very challenging to cope with, both financially and psychologically.

Association of substance abuse and self-injurious behaviour is a well-known phenomenon all over the world.[21,25] The self-harm could well be a consequence of intoxication that resulted in impulsive decision making, poor judgement and aggressive behaviour.[25] Sometimes intoxication can lead to auditory hallucinations or paranoia which can precipitate self-harm.[25] Some others use substances to facilitate self-harm and there are others who use substances as a method of self-harm.[25] In this study, none of the females were found to have used any substance during these incidences. Alcohol was the commonly used substance among the males (46%) followed by Marijuana (Ganja) (04%). The exact association between the substance use and its consequences leading to self-injurious behavior could not be explored in this study.

A history of previous self-injuries is a key risk factor for repeated similar attempts. Previous history likely to use more lethal methods.[21,28,29] According to one study, self-ingestion of a poison was the commonest method (82%) followed by cutting with sharp instruments (13%), hanging (1%) and firearm injuries (1%).[16]

In another study done at Contra Costa county, poisoning (81%) was the commonest method followed by cutting with sharp instruments (11.8%).[17] Similar findings were observed in a study done in Tanzania with poisoning being the most common method (35%) followed by cutting with sharp instruments (23%), jumping from heights (20.6%), hanging (7.4%) and firearm injuries (4.4%).[21] However, in a study done among adolescents, cutting with sharp instrument (35%) was the commonest method followed by firearm injuries (25%), jumping from a height (15%), suffocation (10%) and poisoning (5%).[18] Similar findings were observed in another study conducted in Teheran, Iran, where the most common method used was sharp force trauma (82.7%) followed by blunt trauma (12.4%) and burns with hot objects (3.4%).[5] In this study, male patients had shown similar findings with majority presenting with sharp force injuries. However, none of the males presented with firearm injuries or poisoning. For females also, the commonest method was use of sharp force with none presenting with poisoning.

This study showed that the upper limb was the most frequent body region affected and distribution of lesions were more common on the anterior aspect than on the posterior aspect.

The non-dominant upper extremities including forearms, wrists, and arms were common areas for injury. Other easily accessible areas such as front of the torso, legs, and forehead were the other target sites of self-injury found in this study. Similar anatomical site distribution of the injury was reported by others.[5] Deliberate self-harm is commonly associated with sharp force injuries with superficial cuts and scratches being the commonest type.[5] Bruises, deep cuts and fractures are also known to occur though with much less frequency.[5] Similar findings were observed in this study with 81% presenting with superficial cuts and scratches. Only 2% had deep cuts whereas none had fractures.

According to literature, a majority of the patients with self-injuries presented were with a single injury (58.8%).[5]

However, in this study, a majority of the patients presented were with multiple injuries (71%). Injuries with mild to moderate (80.4%) severity were the commonest while the severe injuries (19.6%) were relatively rare among patients with self-injuries.[5] This is in accordance with this study as well, where 83% of the patients had non-grievous injuries and only 17% had grievous and endangering life type of injuries. All the female patients had only non-grievous injuries. The typical injury pattern of self-injury (multiple, parallel, superficial injuries, excluding vital sites and sparing of clothes)[4] was seen among majority of the patients in this study. Out of that, all the female patients had shown all the typical characteristics of self-injury. Previous history of self-harm was reported in several studies carried out in various parts of the world.[21,26,27]

According to one study, previous self-harm was reported in 2.9% of the patients presented with deliberate self-harm.[21] In this study, 28% of the patients had a history of a similar attempt in the past which was supported by the presence of scarring. This further confirms that individuals with a history of self-injury are more prone for repeated self-injurious behaviours.

According to literature, methods used for deliberate self-harm differs according to gender. Self-poisoning accounts for the majority of self-inflicted injuries in females, whereas males are more likely to use more lethal methods.

CONCLUSIONS

Injuries due to deliberate self-harm is a considerable public health problem which can cause a significant harm especially among the young males. Low level of education, unemployment, substance abuse and presence of a psychiatric illness were among the identified risk factors. The motivations for self-injury are exceedingly diverse and often multifactorial. The types of injuries are diverse as well, ranging from superficial scratches to deep internal injuries. Distinguishing the injuries caused by deliberate self-harm from alleged assaults and accidents can sometimes be difficult and the forensic practitioners should be mindful of this. Most of the findings in this study are in keeping with studies done in other countries. Young males were the most vulnerable group for this type of act and they should be the target group when considering preventive measures.

LIMITATIONS OF THE STUDY

In this study, the analyzed group of patients were selected from a single tertiary care hospital. Therefore, results may not represent the actual situation in other parts of the country. The history of psychiatric illness and use of substance abuse was based on self-reporting from either the patient or relatives and may not be reliable. As this study was a retrospective study, an in-depth analysis in to some of the aspects could not be carried out. However, despite these limitations, findings of this study will help prevention and intervention efforts for those most at risk of deliberate self-harm in this region.

ETHICAL ISSUES

Informed written consent of all patients were obtained during the clinical examination for use of information for scientific communications without divulging the identity of individuals. This study was carried out within the ethical standards set up by the Department of Forensic Medicine, Faculty of Medicine, University of Ruhuna.

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHOR CONTRIBUTIONS

RHAIR: Conception or design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; and final approval of the version to be published. **EGUNG:** Conception or design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; and final approval of the version to be published.

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SPECTRUM OF SUDDEN CARDIAC DEATH IN NEPALESE POPULATION - AN INSTITUTIONAL BASED STUDY -

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ABSTRACT

Introduction: Sudden cardiac death (SCD) is non traumatic deaths occurring within 24 hours from the onset of symptom due to a cardiac cause. This study was designed with an objective to evaluate spectrum of SCD in the Nepalese community.

Materials and Methods: This was a prospective analytical study, done at an autopsy center in Nepal, over one year. All SCD's were verified using histopathological examination. Analysis was done using SPSS, Version-20. Mean and standard deviation was calculated for age. The frequency and percentage were calculated for gender, and cause of death. Stratification was done for age and post-stratification Chi square test or Fisher exact test was used.

Results: There was a total of 51 cases, with 44(86.3%) males and 7(13.7%) females. Peak death was between 40 –60 years. The most common cause of death was coronary artery diseases (CAD) (62.7%). There was significant association of gender with the different spectrum of SCD, with male gender having tendencies towards CAD and cardiomyopathy (CM).

Conclusion: Coronary artery disease is the commonest cause of sudden cardiac deaths, followed by cardiomyopathy. Both these diseases had significantly increased tendencies towards male gender.

INTRODUCTION

Sudden and unexpected natural death is defined as death that is non-violent and not otherwise explained, occurring within 24 hours from the onset of symptom.[1] The most common cause of sudden death is cardiovascular diseases and coronary artery disease is responsible in almost 80% of cases.[2]

Cardiomyopathies (CM) are characterized by myocardial dysfunction and are further categorized into dilated or congestive, hypertrophic, and restrictive-obliterative.[2] The most common is congestive or dilated cardiomyopathy which is characterized by enlargement, sometimes massive, with dilatation of all four chambers.[2]

Valvular disease attributable to sudden cardiac death (SCD) usually involves either mitral valve prolapse or aortic stenosis, which is present in 5 – 15 % of the population.[2]

Aortic dissection occurs when blood dissects between the middle and outer two thirds of the aortic media, creating a blood-filled channel within the aortic wall.[3] Genetic abnormalities, weight-lifting and cocaine abuse have been associated with aortic dissection.[4,5]

Since, there may be racial and geographical variations, this study was designed with the objective of determining the pattern and frequency of sudden cardiac deaths (SCD) in an autopsy center in Nepal.

MATERIALS AND METHODS

This is a prospective analytical study performed at Department of Forensic Medicine, Maharajgunj Medical Campus, Institute of Medicine, Tribhuvan University, Kathmandu, Nepal. This study was performed over the duration of one year, where, a non probability, purposive sampling technique was used. All the cases of sudden and unexpected death of Nepalese citizens brought to the department of Forensic Medicine which was diagnosed to be of cardiac origin was included in this study. Deaths due to trauma, suicide or homicide and all cases of advanced decomposition semi-skeletonized and skeletonized remains were excluded from this study.

All the cases of sudden and unexpected deaths brought to the center underwent medico-legal autopsies and cardiac causes were verified using histopathological analysis in all cases. This information including name, age, and gender were entered into the study proforma. Analysis was done with software SPSS, Version 20. The mean and standard deviation was calculated for age. The frequency and percentage were calculated for gender, and cause of death. The effect modifier like age and gender were controlled through stratification to see the effect of these modifiers on the outcome. Post-stratification Chi square test or Fisher exact test were used where applicable.

RESULTS

There was a total of 51 cases of SCD. Forty-four (86.3%) were male. The peak age of death was 40 – 60 years, with a mean age of 46.59 years (SD= 16.288) (Fig. 1).

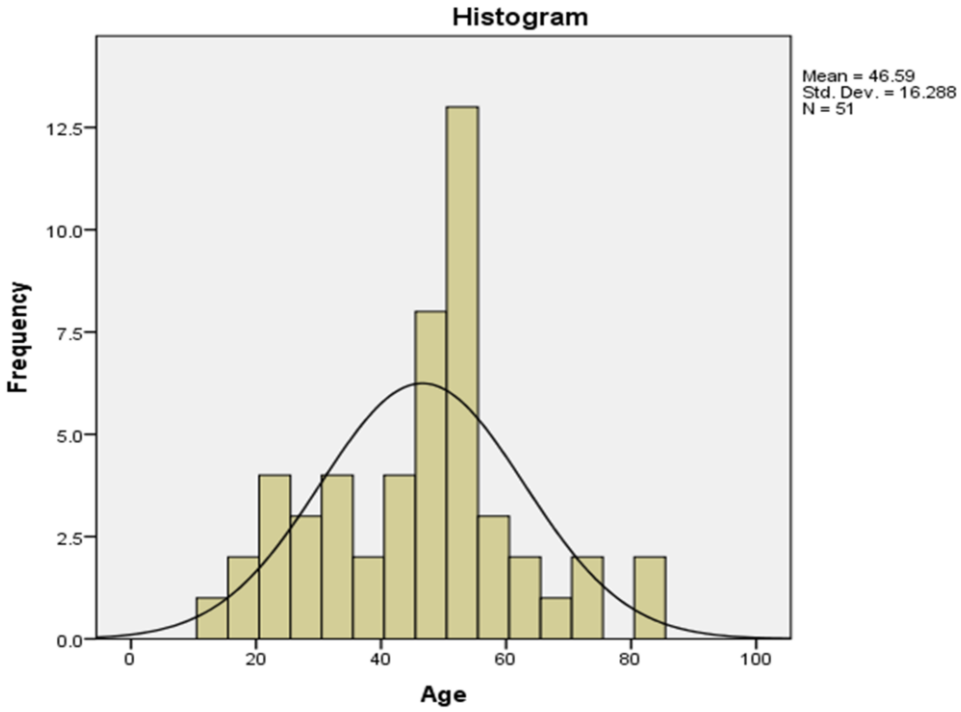

Fig. 1: *Age distribution of the sudden cardiac deaths*

The most common cause of death was coronary artery disease (CAD) which was 62.7% of all the sudden and unexpected cardiac deaths **(Table 1).** These deaths were more common at 50–59 years of age. However, these findings were not statistically significant among the different causes of sudden cardiac deaths **(Table 2).** On the other hand, there was a significant association between gender and the different spectrum of SCD, with male gender having tendencies towards CAD (93.75%, 30/32) and CM (100%, 8/8) **(Table 3).**

Table 1: Spectrum of different causes of sudden and unexpected cardiac deaths

Cause of death	Number of cases
Coronary artery disease (CAD)	32 (62.7 %)
Cardiomyopathy (CM)	8 (15.7 %)
Aortic dissection (AD)	5 (9.8 %)
Valvular heart disease (VHD)	3 (5.9 %)
Dissecting coronary artery	1 (2 %)
Myocardial rupture without CAD	1 (2 %)
Ventricular aneurysm	1 (2 %)

Table 2: Relation of age with the different cardiac causes of deaths

Age Category	AD	CAD	CM	Dissecting coronary artery	Myocardial rupture without CAD	Ventricular aneurysm	VHD	P value
10- 19	0	1	0	0	1	0	1	0.36
20-29	2	2	2	0	0	0	1	
30-39	0	3	1	0	0	0	0	
40-49	2	6	2	1	0	0	0	
50-59	1	13	3	0	0	1	0	
60-69	0	4	0	0	0	0	0	
70-79	0	2	0	0	0	0	0	
80-89	0	1	0	0	0	0	1	
Total	5	32	8	1	1	1	3	

AD: Aortic Dissection, CAD: Coronary Artery Disease, CM: Cardiomyopathy, VHD: Valvular Heart Disease

Table 3: Relation of gender with the different cardiac causes of deaths

Gender	AD	CAD	CM	Dissecting coronary artery	Myocardial rupture without CAD	Ventricular aneurysm	VHD	P value
Female	2	2	0	1	1	0	1	0.008*
Male	3	30	8	0	0	1	2	
Total	5	32	8	1	1	1	3	

AD: Aortic Dissection, CAD: Coronary Artery Disease, CM: Cardiomyopathy, VHD: Valvular Heart Disease

CORONARY ARTERY DISEASE

Single vessel involvement

More than 75% of the lumen of left anterior descending coronary artery (LAD) was stenosed in 20 cases. Among these, six showed features of acute myocardial infarction in histopathological examination, one had developed cardiac tamponade following posterior lateral ventricle rupture at due to acute myocardial infarction, one showed features of old myocardial infarction and three showed features of both acute as well as old myocardial infarction. The other nine cases did not show any cardiac changes on histopathological examination.

There were four cases of right coronary artery (RCA) involvement. Among them, one case was stenosis with only pinpoint opening of lumen (more than 90% blocked) at the level of origin of RCA, and three cases were associated with thrombosis in RCA with more than 75% stenosis. Two out of these three cases had features of acute myocardial infarction on histopathological examination.

Two-vessel involvement

Two vessel involvement was seen in four cases. More than 75% of lumen of LAD and RCA were stenosed in two cases, of which, one case showed features of old myocardial infarction. More than 75% of lumen of LAD and Circumflex artery was stenosed in one case. More than 75% of lumen of RCA and circumflex was stenosed in one case and showed features of old, as well as acute, myocardial infarction.

Triple vessel involvement

There were four cases of triple-vessel involvement with over 75 % of luminal stenosis. Among the cases of triple-vessel disease, one had left postero-lateral ventricular wall rupture following AMI, one had only stenosis and the other two had both features of AMI and old MI.

Cardiomyopathy (CM)

There were eight cases of deaths due to CM, four had dilated CM (Fig. 2) and four had hypertrophic CM (Fig. 3). One of the four cases of dilated CM was alcoholic CM. Three cases of hypertrophic CM were associated with LAD bridging.

***Fig. 2**: Dilated cardiomyopathy, shown in cross section (A), anterior view (B), and posterior view (C)*

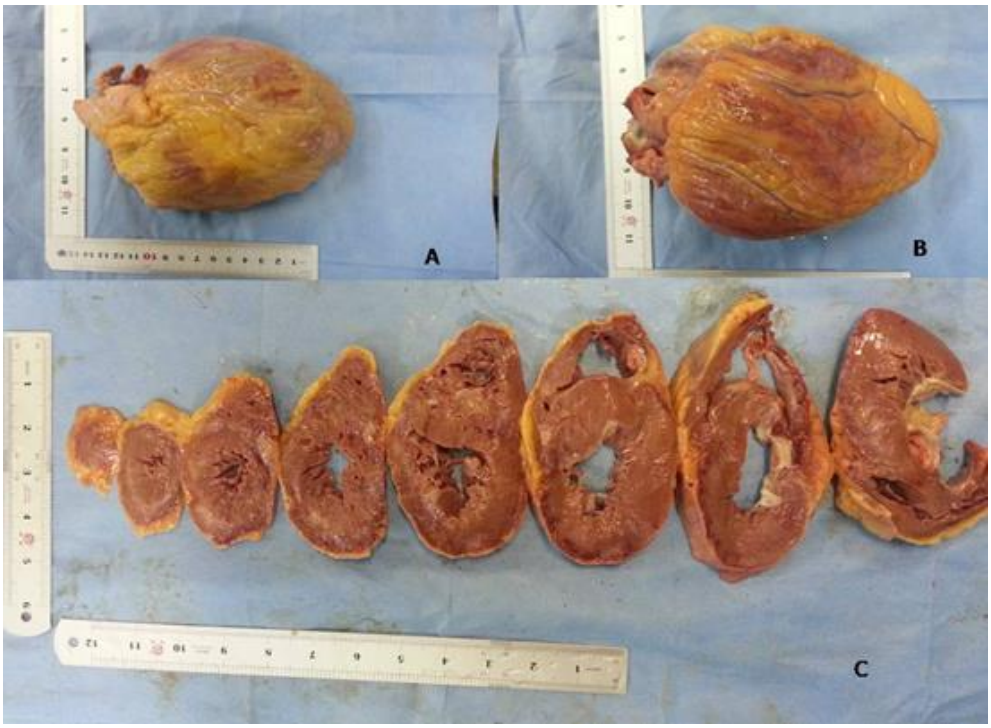

Fig. 3: *Hypertrophic cardiomyopathy, shown in anterior view (A), posterior view (B), and cross-section (C).*

Aortic dissection (AD)

There were five cases of AD with dissection at the level of the ascending aorta (Fig. 4). Four of these cases were associated with cardiac tamponade and one had only intimal dissection occluding only the arterial lumen.

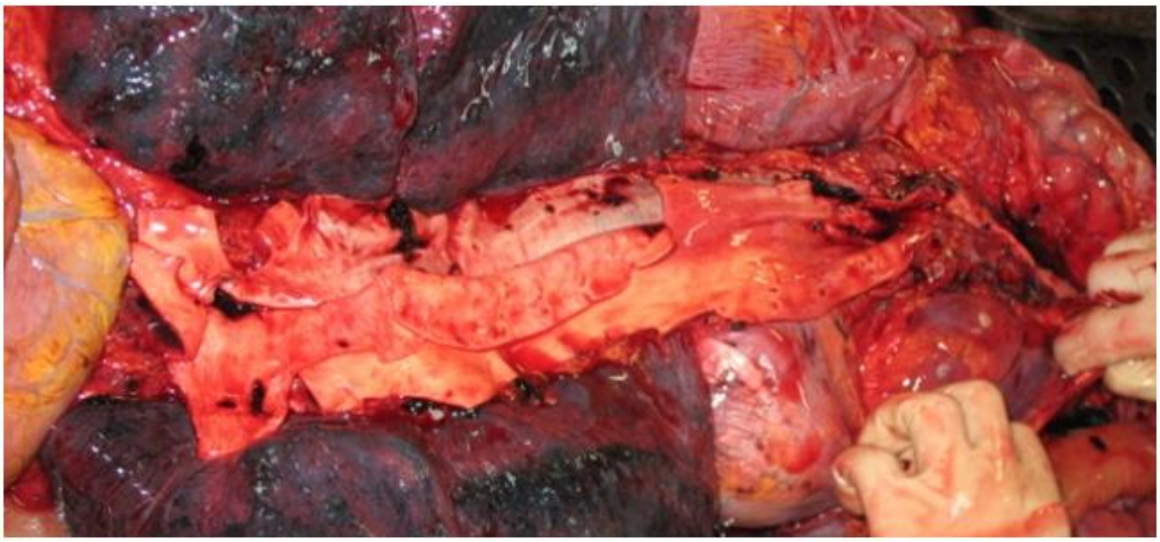

Fig. 4: *Aortic dissection starting from the ascending aorta*

Valvular heart disease (VHD)
There were three deaths due to VHD. One was due to rheumatic heart disease, the second had mitral stenosis with calcified aortic and mitral valves, and the third had aortic stenosis due to primary degenerative calcification.

Dissecting coronary artery
There was one case of a dissecting right coronary artery associated with a cardiac tamponade.

Myocardial rupture without CAD
There were three cases of myocardial rupture where two were ventricular ruptures associated with CAD. However, there was one case of isolated myocardial rupture without CAD, where there was right atrial rupture with cardiac tamponade. This was a 16-year-old syndromic boy with cerebral palsy; however, the exact underlying cause of rupture was unknown.

Ventricular aneurysm
Only one case of ventricular aneurysm was seen which was associated with ventricular scarring at the aneurysm site.

DISCUSSION

Literature revealed that cardiovascular disease is the most common cause of sudden and unexpected natural deaths.[6,7] This study revealed that CAD accounts for the highest number of deaths (62.7 %). This finding is similar to the findings of Zipes and Wellens where up to 80 % of the individuals dying suddenly of cardiac disease died of coronary artery disease.[6]

Coronary artery disease
SCD as a result of a single coronary vessel disease was confined to only 11.9 % in the study of Di Maio et al where 451 deaths due to CAD were analyzed.[7] However, in this study 75 % (24 out of 32 cases) had a single vessel involvement, which is significantly higher than that seen in the Di Maio study. This variation may be attributed to the difference in the nature of the population studied. Among the deaths with a single vessel involvement in our series, 83 % (20/24) were due to the involvement of the LAD (Fig. 2), and this vessel seems to be the main affected artery in other autopsy series as well.[7]

The involvement of two and three vessels among the cases of coronary artery diseases in this study which was only about 25 %, was similar to the findings by DiMaio & Di Maio.[7] De Wood et al in their series had 34.8 % of the deaths attributed to an old infraction and myocardial scarring, and only 8.4 % of the deaths had evidence of AMI associated with CAD.[8] In this study, among the 32 cases of CAD, 62.5 % of the deaths had either an old MI (12.5 %), or AMI (37.5 %), or both (12.5 %.).

Occasionally, other anatomical variations may be seen in the vessels besides coronary atherosclerosis. The death of one case in our series was attributed to a pinpoint opening of the right coronary artery. Similarly, coronary artery disease may have complications such as cardiac rupture leading to cardiac tamponade, which was observed in two case of CAD due to single vessel and triple vessel disease.

Cardiomyopathy
This is associated with myocardial dysfunction of unknown etiology, and is not related to arteriosclerotic, hypertensive, congenital, or valvular disease.[2] In our study, we observed that cardiomyopathy accounted for 15.6 % of deaths due to cardiovascular causes, where 50% was due to dilated and 50% due to hypertrophic cardiomyopathy. Cutler & Wallace had 30 - 50 % of hypertrophic cardiomyopathy deaths in their series associated with bridging of the coronary artery, most commonly the left anterior descending. Sudden death due to this phenomenon was also stressed by Morales et al.[9,10]

In this study, there were three LAD bridging out of four cases of hypertrophic CM.

We had no cases of restrictive-obliterative CM in this study, and it has been noticed that this category of CM rarely causes sudden and unexpected death and is usually associated with other chronic diseases like amyloidosis, haemochromatosis, sarcoidosis, glycogen storage disease, and hypereosinophilic syndrome.

Aortic dissection (AD)

Pathologically, in AD, there is blood dissecting between the middle and outer two thirds of the aortic media, which forms a blood-filled channel in the aortic media.[3] This is more common in the ascending aorta and this dissection can rupture into the lumen of the aorta or into the pericardial sac.[3,7] In this study, 9.8 % of deaths due to cardiovascular causes were due to this pathology and all of them were at the level of ascending aorta. Davies et al. also report that this is overwhelmingly the most common site. Our series had 80 % of the aortic dissections, associated with cardiac tamponade.[3]

Valvular heart disease, dissecting coronary artery, myocardial rupture without CAD, and ventricular aneurysm

The exact proportion of deaths due to valvular heart diseases was difficult to extract from the literature, although valvular heart disease is quoted as one of the common causes of deaths due to cardiovascular causes.[11] The most common cause of sudden death as a result of valvular heart disease seems to be mitral valve prolapse followed by aortic stenosis and acute bacterial valvulitis as per Selzer.[11] However, in this study there were only three cases of sudden and unexpected deaths due to valvular heart disease, and thus not a common cardiovascular cause of death in our series.

A few rare cases of sudden and unexpected deaths due to cardiovascular causes were also encountered in this study; dissecting coronary artery, myocardial rupture (two associated with coronary artery disease and one not associated with coronary artery disease), and a case of ventricular aneurysm.

CONCLUSION

Coronary artery disease is the commonest cause of sudden cardiac deaths, followed by cardiomyopathy. Both these diseases were significantly higher in males.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHOR CONTRIBUTIONS

AC: Data collection and report writing;
TK: Data analysis;
HW: Critical revision and final approval;
PKS: Concept and design of work

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A DEATH DUE TO ACUTE AORTIC DISSECTION

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ABSTRACT

Acute aortic syndrome (AAS) is a term used to describe a collection of life-threatening aortic disease conditions that have similar presentations, but differ in their demographic, pathological, clinical and other characteristics. The exact number of deaths due to AAS is unknown. However studies suggest that the majority of deaths in AAS are due to acute aortic dissection. A 51-year-old male developed sudden onset chest pain while he was taking a bath in the evening. It was a sharp, tearing type chest pain, which was radiating to the left side of his neck. On admission to hospital his low blood pressure was found to be low. He suffered cardiac arrest a few minutes later and died without regaining consciousness. Post-mortem examination revealed a massive haemopericardium (600 ml). Aortic dissection was identified extending from the aortic root to the lower part of the descending abdominal aorta. The thickest point of the dissection was 1.5 cm. There was an intimal tear inferiorly. The dissection extended through the aortic arch to the descending aorta ending 1 cm above the renal artery branching point. Sections of the aorta showed cystic medial degeneration with prominent pools of mucin. Mild atheroma was seen in some sections. The presence of aortic dissection was confirmed. The cause of death was given as haemopericardium due to ruptured aortic dissection. Acute aortic dissection may mimic other cardiovascular conditions, especially ischemic cardiac events. Therefore, the clinical suspicion and a comprehensive history-taking are the key for an early diagnosis. Careful dissection of the aorta and its branches is essential when making a post-mortem diagnosis of aortic dissection. Proper histopathology examination of the aorta assisted immensely in confirming the diagnosis.

INTRODUCTION

Acute aortic syndrome (AAS) is a term used to describe a collection of life-threatening aortic disease conditions that have similar presentations, but differ in their demographic, pathological, clinical and other characteristics.[1] Diseases of aorta and its branches accounts for approximately 43,000 to 47,000 deaths annually in the United States alone.[2] The three major diseases that comprise the AAS includes aortic dissection (AD), intramural haematoma (IMH) and penetrating aortic ulcer (PAU).[2] The differentiation between these conditions is difficult as all of them present with acute onset severe chest or back pain with similar radiological findings.[2] The exact number of deaths due to AAS is unknown. However autopsy studies suggest that the majority of deaths in AAS are due to acute aortic dissection.[2] The annual incidence of aortic dissections in the United States is around 3-4 cases per 100 000.[3]

Preadmission mortality is reported to be around 20% whereas it is around 30% in hospital admissions.[3,4] The annual incidence is reported to be 6 cases per 100,000 in United Kingdom whereas it ranged from 9.1 per 100,000 in women to 16.3 per 100,000 in men in Sweden.[5]

There are two leading theories regarding the development of aortic dissection.[6] In the first, the development of an intimal tear is believed to be the triggering event, which is followed by seepage of blood from the aortic lumen to the already weakened medial space due to elastic degeneration and smooth muscle cell loss. In the second theory rupture of the vasa vasorum is the initial event, which leads to bleeding within the aortic wall which subsequently leads to intimal disruptions and propagation of a dissection flap.

The propagation of the aortic dissection usually happens in an ante grade manner due to the pressure wave exerted through the left ventricle, though the retro grade propagation is also a possibility.[6] The expansion of the false lumen can lead to compression of the true lumen with resultant under perfusion of vital organs. The ultimate life-threatening complications could include pericardial effusion causing cardiac tamponade, exsanguination from aortic rupture, cardiac ischaemia and myocardial infarction, cerebrovascular accidents, mesenteric ischaemia, ischaemic colitis and spinal ischaemia.[6]

CASE REPORT

A 51-year-old male, who was a heavy smoker and an alcoholic, without any significant past medical history, developed sudden onset chest pain while he was taking a bath in the evening. It was a sharp, tearing type chest pain, which radiated to the left side of his neck. He had returned home after a hard day's work and had consumed alcohol on his way home. He has not had such chest pain in the past. Later he complained of severe back ache and difficulty in breathing. He was taken to the closest hospital by his family members, from where he was transferred to a Teaching hospital. He was found to have a low blood pressure on admission. He went into cardiac arrest few minutes later. Cardio-pulmonary resuscitation was provided for 30 minutes without any success. An inquest was requested by the attending doctors and the Inquirer into Sudden death ordered a post-mortem examination.

The body was that of an adult male with features in keeping with the stated age, weighing 66 kilograms and measuring approximately 168 cm in height with a body mass index of 23.5 kg/m^2. No injuries were identified. There were no discharges present at ear, nose or throat.

The heart weighed 390 g. The pericardial cavity contained approximately 600 ml of predominantly liquid and some clotted blood. Epicardium was unremarkable. No acute ischaemic changes were seen in the myocardium. The right ventricular wall thickness was 4 mm. The left ventricular free wall thickness was 14 mm. The interventricular septum measured 13 mm in thickness. The endocardium appeared unremarkable. The cardiac valves were normal in configuration. The coronary arteries were normal in configuration with a right dominant circulation. The right and left coronary ostia were patent. There was mild calcific atherosclerosis of all three vessels without significant stenosis. There was an aortic dissection extending from the aortic root (Fig. 1) to the lower part of the descending abdominal aorta (Fig. 2). The thickest point of the dissection was 1.5 cm. There was an intimal tear inferiorly. The dissection extended through the aortic arch to the descending aorta ending 1 cm above the renal artery branching point. The renal arteries and distal branches were not involved. Fatty streaks and atherosclerotic changes were noted in the aortic arch and the descending aorta.

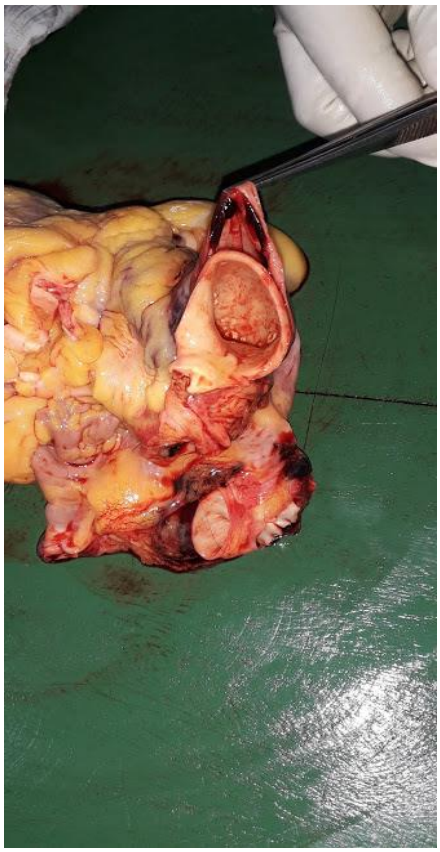

Fig. 1: *Aortic dissection involving the root of aorta*

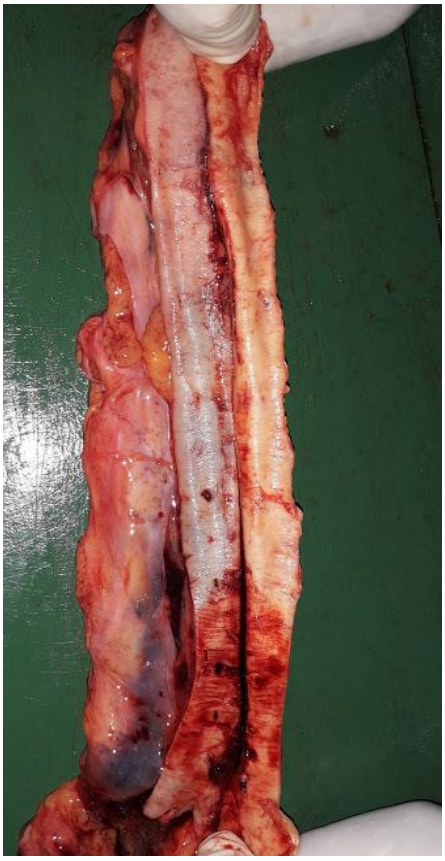

Fig.2: *Aortic dissection extending in to the descending aorta*

Both pleural cavities were free from plaques. The visceral pleurae were smooth. The left lung weighed 490 g and the right lung weighed 482 g. Both lungs appeared well inflated. There was no consolidation or collapse. No focal mass lesions were identified. There was no thrombosis or infarction. The brain was normal in configuration. No appreciable gyral atrophy was seen. Serial coronal sections through the cerebral hemispheres revealed no abnormality of the cerebral cortex, underlying white matter or basal ganglia. The stomach contained semi digested food. The liver weighed 1710 g. The capsule was intact and the parenchyma was fatty with early signs of cirrhosis. The left kidney weighed 130 g and the right 145 g. On cut section the cortices were of normal thickness and the cortico-medullary junction was well defined. The renal papillae and renal pelvis were unremarkable. The ureters were unobstructed. There was no obvious lymphadenopathy. The spleen weighed 165 g and was unremarkable.

Histopathology of all organs were performed. The myocardium showed mild perivascular and interstitial fibrosis with some associated cardiomyocyte hypertrophy. There were no acute ischaemic changes. Coronary Arteries showed up to 30% stenosis. There was no luminal thrombus. Sections of the aorta showed cystic medial degeneration with prominent pools of mucin. Mild atheroma was seen in some sections. The presence of aortic dissection was confirmed (Fig. 3, Fig 4).

The lungs showed moderate amount of pulmonary oedema with intra-alveolar, haemosiderin laden macro phages. The liver showed largely preserved lobular architecture with macrovescicular fatty change and early bridging fibrosis. No interface or lobular hepatitis was present. The kidneys showed rare globally sclerosed glomeruli and occasional periglomerular fibrosis. The arteries showed minimal intimal thickening. There was no significant inflammation.

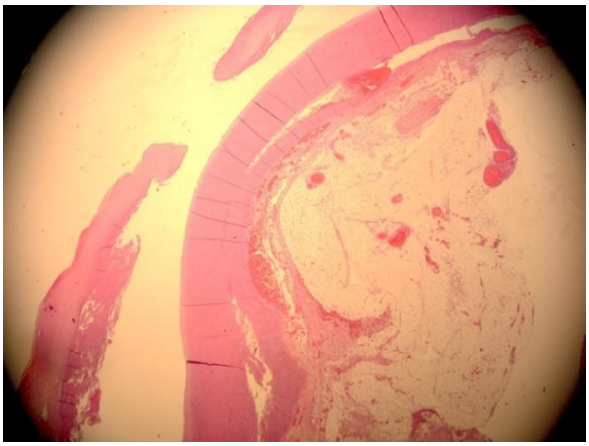

Fig. 3: *Histopathology of the aortic dissection (H & E stain – low power) - note the defect in tunica media, cystic medial degeneration with disruption of the elastic lamina and abundant fresh blood in the adventitia*

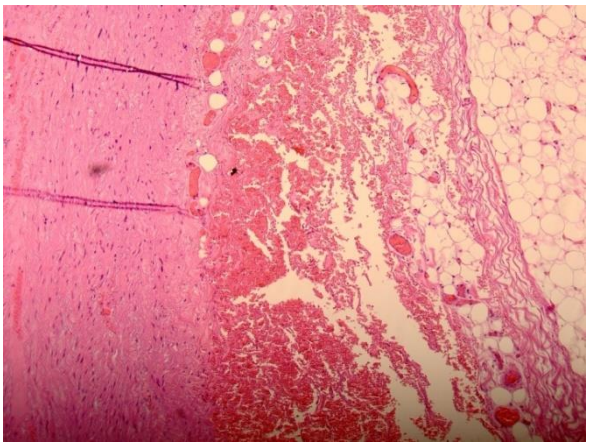

Fig. 4: *Histopathology of the aortic dissection (H & E stain – high power) - note the defect in tunica media, cystic medial degeneration with disruption of the elastic lamina and abundant fresh blood in the adventitia*

The cause of death was given as haemopericardium due to ruptured aortic dissection.

DISCUSSION

Aortic dissection is relatively uncommon but is a devastating condition, because once it occurs, it may lead to acute haemodynamic compromise. The location of the entry tear plays a key role in treatment and outcome.[3] The two commonly used classifications in aortic dissections are Stanford classification and DeBakey classification.[3,5,6] Both these classifications are based on anatomical location and the extent of the dissection flap. In Stanford classification, type A comprises of all dissections that affect the ascending aorta, whereas type B includes all dissections that do not affect the ascending aorta (begins distal to the origin of the left subclavian artery, involving the descending aorta and/or abdominal aorta, without affecting the ascending aorta). According to DeBakey classification, type I dissection originates in the ascending aorta; propagates at least to the aortic arch and often beyond distally. The type II dissection originates and confined to the ascending aorta alone whereas type III dissections are limited to the descending aorta. These classifications systems allow for a standard language in describing aortic pathology, and also reflect the importance of anatomic location of aortic dissection in dictating treatment and determining prognosis.

Ascending aorta is affected twice as that of descending aorta in acute aortic dissection. Aortic dissection involving ascending aorta is mostly found among patients in the age group of 50 to 60 years whereas aortic dissection involving descending aorta is commonly found in the age group of 60 to 70 years.[4,5,6] The acute type A dissection which involves the ascending aorta is a surgical emergency.[7]

This carries a mortality rate of 1–2% per hour within the first day and up to 50% within the first 48 hours if left untreated.[7,8] The acute type B dissection is not as life threatening as Type A dissection, however it also has a mortality rate of 10% within the first month.[7]

In this case, the dissection was found to be involving the ascending aorta, aortic arch and the descending aorta running up to the origin of renal arteries. According to Stanford classification, it is a Type A dissection, whereas according to DeBakey classification, it is a type I dissection. As the literature suggested, the type A dissections present more abruptly with high mortality rate.

This patient collapsed within 2 hours of development of initial symptoms and did not recover afterwards.

Patients with acute aortic dissection, typically presents with sudden onset, sharp, tearing or stabbing type chest pain.[3] Some may present with back or abdominal pain as well.[9] Sudden onset of severe, sharp chest pain is the classic presenting symptom in type A dissection.[6]

Type B dissections are more commonly associated with abdominal pain[6] and back pain than type A dissection. In type A dissection, this pain usually radiates to the neck whereas in type B dissection, it radiates to the interscapular region.[3] Pain may be absent in 10% of the patients.[3] This asymptomatic presentation is mostly seen among diabetic patients.[3] The presenting symptom of chest pain can sometimes mimic that of acute coronary syndrome. The possibility of acute aortic dissection extending into the coronary ostia, there by actually causing an acute ischaemic event, further complicates the presentation. Therefore, in every suspected cardiac ischaemic event, acute aortic dissection should be considered as one of the differential diagnosis.[9] Some patients can present with sudden loss of consciousness if the acute aortic dissection causes a rapid blood loss.[3] Syncope is another important presenting symptom of acute aortic dissection and it could be due to complications such as cardiac tamponade or carotid dissection.[9] Dissection related occlusion of aortic branches can lead to ischemia in any adjacent organs.[9] Interrupted perfusion may result in neurological complications, limb ischemia and visceral ischemia.[3] From a hemodynamic perspective, the blood pressure can be high or low in different patients with acute aortic dissections. Hypotension is commonly seen in patients with type A dissection whereas in type B dissection, hypertension is the predominant finding.[3]

The presenting complaint in this case was sudden severe chest pain of abrupt onset, which radiated to the left side of neck.

On admission to the hospital, he was found to have a low blood pressure. These presenting features are suggestive of a Type A dissection and the differentiation from an acute coronary event based only from these findings is very difficult.

A variety of risk factors are known among patients with aortic dissection. It can affect men and women of all ages but is most commonly seen in men between 60 and 80 years of age.[7] Risk factors for aortic dissection can be divided into iatrogenic, acquired and inherited categories.[6]

Iatrogenic causes accounts for approximately 5% of aortic dissections.[6] Percutaneous procedures and cardiac surgery are among the common iatrogenic causes that predispose to aortic dissection. Aortic dissection is estimated to occur in 0.02% of cardiac catheterization procedures.[6] A higher incidence (0.03%) is reported during percutaneous coronary intervention. Patients undergoing open-heart surgery have an increased risk of developing aortic dissection and these are typically Type A dissections.[6] In this case, this patient has not undergone any of these procedures.

Among the acquired risk factors, hypertension (present in 75%)[6,10] and atherosclerosis (present in 30%)[6,11] are commonly seen among patients with aortic dissection. Hypertension is a more common finding in patients with type B dissections (70%) than in type A dissection (36%).[6,11] Hypertension, pregnancy, cocaine and amphetamine abuse, high intensity weight lifting and heavy exercise are all known to cause increase stroke volume and intra-aortic pressure, thereby weakening the arterial wall, predisposing to the development of aortic dissection.[6] Tobacco use and smoking are known additional risk factors. They can cause medial wall degeneration through breakdown of collagen and elastin, thereby increasing the risk of aortic dissection.[6]

In this case, this patient was a heavy smoker. He also was a manual worker who used to lift heavy weights on a regular basis. These factors would have increased the risk of developing aortic dissection.

Certain connective tissue disorders can cause inherent weakening of the aortic wall and subsequent aortic dissection. Syndromes such as Marfan with fibrillin defects, Ehlers– Danlos type IV with abnormal synthesis of type III procollagen, Loeys–Dietz, annulo-aortic ectasia, familial aortic dissection and other connective tissue disorders associated with cystic medial necrosis are among the well-known causes.[3,6] Aortic dissection is six times more common among patients with Turner syndrome.[6] Patients with certain congenital cardiovascular abnormalities are known to have a higher risk in developing aortic dissections. Conditions such as bicuspid aortic valves and coarctation of aorta are among the well-known associated causes.[3]

In this case, this patient did not have a history of any of these mentioned disease conditions. Family members were unaware of any of these conditions among any of them. However, a proper screening and genetic counselling among the remaining members are important as these syndromes may go unreported.

CONCLUSIONS

Acute aortic dissection may mimic other cardiovascular conditions, especially ischemic cardiac events. Therefore, clinical suspicion and comprehensive history-taking are key for an early diagnosis. The importance of having a thorough knowledge on predisposing conditions and characteristic clinical features is highlighted here. Careful dissection of the aorta and its branches is essential when making a post-mortem diagnosis of aortic dissection. Proper histopathological examination of the aorta assisted immensely in confirming the diagnosis.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHOR CONTRIBUTIONS

RHAIR: Conception or design of the work, interpretation of data for the work and drafting the work.

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A NOVEL TECHNIQUE TO DETECT CHLOROFORM AT TRACE LEVELS IN BIOLOGICAL SPECIMENS AND OTHER ITEMS

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ABSTRACT

The ability to confirm chloroform at trace levels in autopsy specimens and relevant contaminated items is a challenge to the forensic toxicologist.

This paper reveals how sensitive and selective headspace gas chromatography- mass spectrometric method was developed to detect chloroform at trace levels in blood in two cases in Sri Lanka.

Chloroform in suspected items was extracted into methanol. Separation was performed on a 60 m x 0.32 mm capillary column GC-GASPRO. The qualitative and quantitative analysis of chloroform was performed in the scan and single ion monitoring (SIM) modes respectively using mass spectrophotometric detector. The method was validated in terms of linearity (r^2 = 0.993) for the concentrations ranging from 5-100 mg/L, repeatability (RSD – 4.1 % at 10 mg/L, n= 6), limit of detection 1 mg/L and limit of quantification 3.3 mg/L.

In a case of sexual assault toxicological analysis of the contents of the chemical bottle revealed the presence of chloroform at a concentration of 422 mg/L and traces of chloroform on a piece of cloth.

In the case of hanging Chloroform was identified in the concentration of 72 mg/L in blood and traces were found in the empty bottle found at the scene.

INTRODUCTION

Chloroform is used in the chemical industry for synthetic purposes and laboratories as an extraction solvent. Hence, people have free access to chloroform which can be used for criminal activities. Chloroform (Trichloromethane, $CHCl_3$) is commonly known as "knockout drug" as it has a sedative property that causes central nervous and respiratory system depression instantaneously.[1-4] Historically, chloroform has been used as a surgical anaesthetic. However, its use has become obsolete due to adverse side effects such as hepatic and renal cancer.[1,5] Chloroform-induced toxicity is due to production of reactive metabolites during the metabolism of chloroform in liver and kidney. Oxidative dichlorination of chloroform leading to the formation of phosgene ($COCl_2$) which causes the depletion of glutathione will induce cellular toxicity.[4] Reduction of chloroform in the body results the formation of cancer triggering reactive dichloromethyl radical ($*CHCl_2$).[4,5] In literature, there have been several cases reported on chloroform poisoning by forced inhalation during criminal activities such as homicide, suicide and sexual assault.[1,2,4,6-9]

The critical factor in toxicology is to identify chloroform at trace levels in biological post mortem samples and other suspect items associated with criminal activities. In early days, steam distillation or organic solvent extraction methods have been used to extract chloroform from blood and gas chromatograph with electron capture detector or colourimetric methods used for its detection.[6,10] Later a few methods using headspace gas chromatograph coupled with mass spectrophotometer detector have been reported for the determination of chloroform in trace levels.[1,2,6,8] Only a single method acquired more sensitive single ion monitoring mode (SIM) for the quantitative analysis was found in the literature.[2] This study describes a more reliable method for the detection of chloroform in post mortem specimens and related items.

OBJECTIVE

To develop a sensitive and selective headspace gas chromatography-mass spectrometric method (HS-GC/MS) for the detection of chloroform at trace levels in biological specimens and other items.

MATERIALS AND METHOD

Analytical grade Chloroform (purity 99.5%) and methanol (purity 99.8%) were used in the analysis. The instrument used was Agilent 7697A headspace auto sampler gas chromatograph (Agilent 6890) equipped with Agilent 5973N mass spectrophotometer. Capillary column 60 m x 0.32 mm GS-GASPRO, headspace vials (22 mL), vial septum and aluminium caps were used. The mass detector was linked to a data-handling system with Agilent MSD ChemStation integration software (E.02.02.1431) for data acquisition. Helium was used as carrier gas.

Chloroform stock solution was prepared by dissolving chloroform in methanol. The working solutions were prepared by diluting the stock solution with 20% of methanol. Chloroform in suspected chloroform soaked items was extracted into methanol by addition of 5 -10 mL of methanol and mixed well, then squeezed methanol into container which can be tightly cap. Chloroform spiked blood samples were prepared by adding blank blood (0.5 mL), known concentration of chloroform working solution (0.1 mL) and deionized water (0.4 mL) into a headspace vial. Test samples (blood or suspected liquid) 0.5 mL with 0.5 mL deionized water or methanol extract (1.00 mL) was transferred into headspace vial and rapidly sealed with a septum and aluminium cap to prevent any loss of chloroform.

The sealed vials were introduced in an auto-sampling system for volatilization (90 ^{0}C for 12.5 min) and GC cycle time 30.0 min. transfer line temperature was set to 100 ^{0}C and carrier gas flow rate was 2 mL/min. Split mode injection was done with split ratio 1:1 and front inlet temperature was set to 200 ^{0}C, pressure 15.7 psi. The initial oven temperature was 50 ^{0}C for 2.0 min and was increased to 230 ^{0}C at 25 ^{0}C/min and held for 3.0 min. The total run time for gas chromatography was 12.2 min. Identification of chloroform was performed in the scan mode (*m/z* 25 to 250). Obtained mass spectra were compared with NIST-14 library. The method was validated according to Eurochem guidelines.[12] Quantification of chloroform was performed single ion monitoring mode (SIM); *m/z* 83, 47.1 and 35.1 using calibration curve (5-100 mg/L). Limit of detection (LOD) and limit of quantification (LOQ) were obtained by injecting six blank samples spiked with lowest concentration of chloroform. LOD was calculated by; mean value of above six replicates + 3 x standard deviation and LOQ was calculated by; mean value of above six replicates + 6 x standard deviation.

Case I

A woman declared that her former boyfriend smothered her with a cloth soaked in some chemical. She had fallen asleep with intermittent spells of wakefulness during which she has screamed for help. A neighbours had heard her screams and entered the house with others. The victim had been lying naked with her hands and legs tied to a bed. The police was informed immediately. Investigation revealed a piece of cloth on one of the pillows, a screw capped bottle containing a colour-less liquid and used condoms. The piece of cloth and bottle were sent to the forensic toxicology laboratory, Government Analyst's department for toxicological investigation. During this time the suspect was apprehended.

Case II

A 30 year old male was found hanging in his residence. His nose and mouth were said to have been covered with a face mask with a plastic cup inserted. Post-mortem blood and an empty bottle found at the scene were sent to the laboratory for toxicological investigations.

All the samples of case I and II were stored in cold room at +4 ^{0}C.

RESULTS AND DISCUSSION

The developed technique was applied to the above cases and found to be acceptable with respect to all validation parameters.

In blank blood sample, no interfering peak was detected at the retention time of chloroform. This confirmed the absence of interfering endogenous substances. The correlation coefficient (R^2) for the calibration curve concentration ranging 5-100 mg/L was 0.993. This revealed that the method is linear. The inter day relative standard deviation (RSD) for ten injections of 10 mg/L chloroform solution was 4.1 % which is an acceptable value (< 5%) for a validated method. Limit of detection and limit of quantification were 1 mg/L and 3.3 mg/L respectively.

Table 1: Method validation parameters for chloroform

Chloroform validation parameters						
Calibration range	RT	R^2	Calibration equation	RSD	LOD	LOQ
5-100 mg/L	9.27 min	0.993	y = 370.73x + 1972.8	4.1 %	1 mg/L	3.3 mg/L

RT- retention time

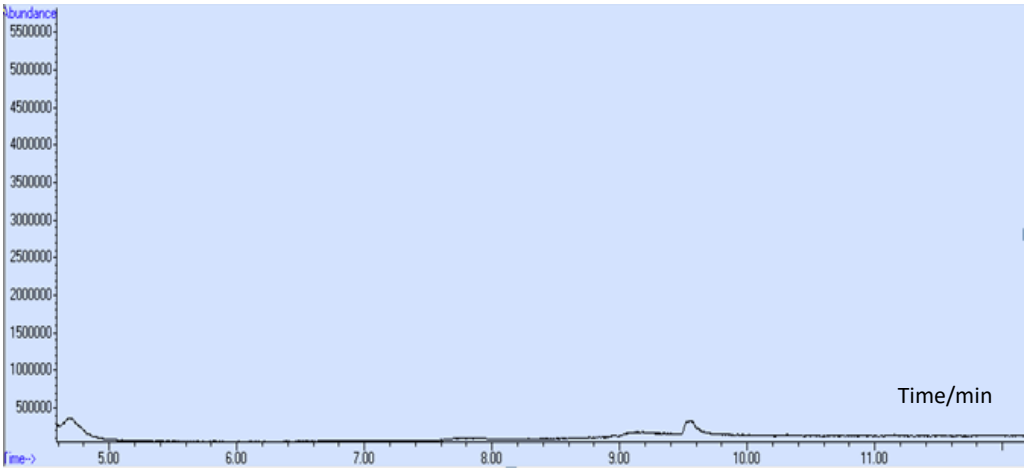

Fig.1: *HS-GC/MS; Total Ion Chromatogarm (TIC) for blank blood*

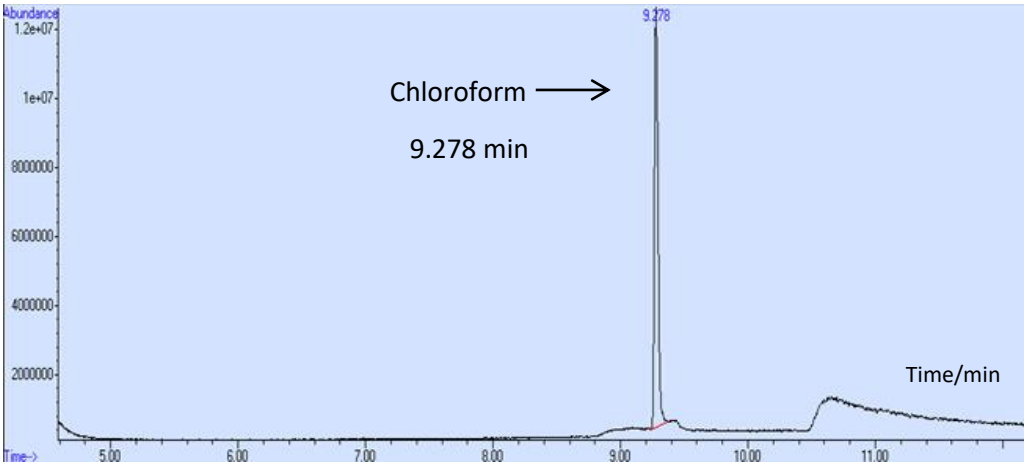

Fig.2: *HS-GC/MS; Total Ion Chromatogarm (TIC) for chloroform in blood*

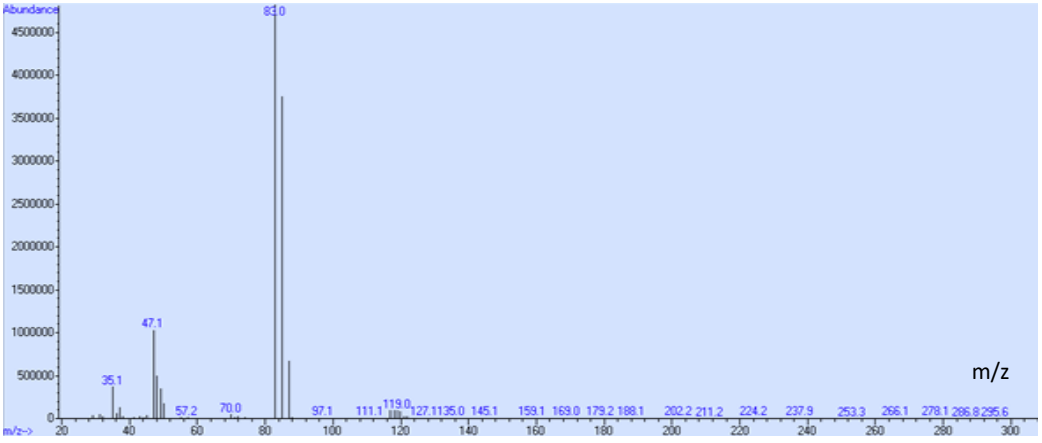

Fig.3: *HS-GC/MS; Mass Spectrum of chloroform obtained from chloroform positive blood*

On the toxicological analysis of samples in case I, chloroform 422 mg/L was identified in the liquid in the suspected bottle and traces of chloroform were detected on the piece of cloth. Analysis by HS-GC/MS of case II samples revealed the presence of chloroform. The post-mortem blood contained 72 mg/L of chloroform and traces in the empty bottle. Baselt and Carvey reported that concentrations of chloroform ranging from 10-194 mg/L with an average of 64 mg/L have been found in fatal cases.[11] Rißе et al have reported chloroform levels of 73 to 115 mg/L in postmortem blood of homicides.8 Further Meichsner et al have reported that 47 mg/L of chloroform was found in postmortem blood of suicidal poisoning by chloroform inhalation.[13] Chloroform exposure was lethal for the victim of suicidal hanging in case II. Rißе et al reported that total loss of chloroform from blood stored at +4 ^{0}C is markedly less.[8] Hence, there was no chloroform loss in analysed blood sample as we stored it in the said condition.

Conclusions

The reported cases were the first cases where trace levels of chloroform were identified in blood and objects in Sri Lanka using headspace gas chromatography mass spectrometry.

The study illustrates that chloroform can be detected and quantified at trace levels from blood. Further, the analytical findings provide corroborative evidence to the criminal intent.

ETHICAL ISSUES

None

CONFLICT OF INTEREST

None

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AUTHOR CONTRIBUTIONS

LSH: Design of study, Experimental work, Analysid of data and Writing of manuscript; **AW:** Design of study, Experimental work, Analysid of data and Writing of manuscript; **WDVK:** Design of study, Experimental work, Analysid of data and Writing of manuscript; **TRMCDM:** Design of study, Experimental work, Analysid of data and Writing of manuscript

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LEGISLATION MADE FOUR DECADES AGO ON "SMELLING OF LIQUOR": ERRONEOUS IN THE CONTEXT OF CURRENT SCIENTIFIC KNOWLEDGE

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ABSTRACT

Science has evolved radically during the last few decades. Therefore, certain legislation made based on the scientific knowledge of a particular era, should be reviewed in the context of new knowledge in the field of science.

Section 11 of the 'Offences committed under the influence of liquor (special provisions) act no. 41 of 1979' states that 'A person shall be presumed to be under the influence of liquor if at or about the time of the commission of the act he is smelling of liquor …. unless evidence to the contrary has been adduced.' An endorsement to the presence of breath smelling of alcohol by the medical expert in the Medico-Legal Examination Form could lead to a conviction under this act.

Ethyl alcohol is almost odourless and its smell is due to the presence of volatile substances called congeners produced simultaneously during the process of fermentation of ethyl alcohol. Therefore, the odour of alcohol frequently detected on people after consumption of alcoholic beverages is not due to alcohol, but to by-products of alcohol manufacture known as congeners.

In addition, this odour may persist in the tissues for several hours even after the alcohol has been eliminated from the body.

Therefore, the legal presumption that alcohol is present in blood, based upon the smell of liquor is erroneous. Conviction upon smelling of liquor should be stopped with immediate effect and the said legislation should be amended. Further, the Medico-Legal Examination Form should also be amended in this regard.

INTRODUCTION

The smell of liquor is a legally accepted indicator of 'drunkenness' in Sri Lanka. Section 11 of the 'Offences committed under the influence of liquor (special provisions) act no. 41 of 1979' states that 'A person shall be presumed to be under the influence of liquor if at or about the time of the commission of the act he is smelling of liquor …. unless evidence to the contrary has been adduced.'[1] Accordingly, it is presumed that for the purpose of this act, a person is under influence of alcohol, if he was smelling of liquor at or about the time of commission of act.

In the subsequent interpretation of the same act, it is mentioned that "liquor" includes spirit, wine, toddy, beer, and all liquid consisting of or containing alcohol.[2]

Widely consumed alcoholic beverages contain ethyl alcohol. For the purpose of this paper, it is assumed that the term meant by 'alcohol' in the said law is ethyl alcohol.

Upon conviction, the said person shall be liable to be punished with imprisonment of either description for a term of not less than six months, and not exceeding two years, and shall also be liable to a fine of not less than one thousand rupees and not exceeding two thousand five hundred rupees.[3]

Based on this indicator, police seek scientific evidence from medical experts through the Medico-Legal Examination Form (MLEF) on whether a certain person was smelling of liquor which would lead to subsequent prosecution under this law. For this purpose, there is a tick box with 'breath smelling of alcohol' in the MLEF where a medical expert needs to indicate the status. An endorsement to the presence of alcohol smell in the breath by the medical expert in the MLEF could lead to a conviction under this act.

However, does the breath really smell of ethyl alcohol?

Ethyl alcohol is almost odourless and its smell is considered to be due to the presence of volatile substances called congeners, produced simultaneously during the process of fermentation of ethyl alcohol.[4] Sometimes aromatic congeners are wittingly added to some alcoholic beverages of inferior quality to produce an odour to convince consumers that a particular beverage is of good quality.[5] These include, acetone, acetaldehyde, esters, tannins, and aldehydes.[4] Therefore the "odour of alcohol" frequently detected on people after consumption of alcoholic beverages is not due to alcohol but to by-products of alcohol manufacture or congeners.[5]

The smell of an alcoholic beverage can persist in tissues and breath for several hours after all the alcohol has been metabolized or eliminated from the body.[5,6] A situation has been encountered where an odour of alcohol was detected at autopsy but the blood alcohol levels were negative.[5] It is also possible that a person who has consumed another beverage containing the said congeners will "smell of alcohol" . The reason for this is that the metabolic pathways of degradation of ethyl alcohol and the rest of the congeners are different in the body. Therefore it should be noted that congeners can enter the human body even without consumption of alcohol or be produced naturally in the human body.

Acetone is produced naturally in the human body during ketoacidosis and gives the characteristic alcohol smell in breath. Alcohol free beverages, jams, bread, vegetables, fruits and milk contain Acetaldehyde[7]. Esters are present in commonly consumed fruits and vegetables, such as apples, apricots, mandarins, mangoes, papayas, red and chili peppers, potatoes or squash.[8] Tannins have been found in a variety of plants utilized as food and feed such as sorghum, millets barley, legumes, dry beans, pomegranates, cranberries, blueberries, hazelnuts, walnuts, pecans, peanuts, chickpea.[9] Aldehydes are formed endogenously by lipid peroxidation, carbohydrate or metabolism ascorbate autoxidation, amine oxidases, cytochrome P-450s, or myeloperoxidase-catalyzed metabolic activation.[10] In addition, dietary aldehydes and drugs that are aldehydes or reactive aldehyde metabolites can introduce aldehydes in to the body without consumption of alcohol.[10]

In addition, the said substances are also present as excipient in some herbal medicines and pharmaceutical drugs.[11] Salicylic acid acetate, or aspirin, is one of many esters used as medicines. Phenyl salicylate, a similar aromatic ester, is used in the treatment of rheumatic arthritis. Methyl phenidate, an ester is used to stimulate the central nervous system. The pharmaceutical industry has discovered that certain undesirable properties of drugs, such as bad taste or swelling of the skin at the spot of an injection, can be avoided by converting the original drug into an ester. The antibiotic clindamycin, a bitter tasting drug, was converted to its palmitate ester in order to make its flavor less harsh.[11]

CONCLUSION

Therefore, the legal presumption that alcohol is present in blood, based upon the "smell of liquor" is erroneous from a scientific and evidence based perspectives. Conviction upon the "smell of liquor" should be stopped with immediate effect and the said legislation should be amended. Further the MLEF should also be amended in this regard.

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FORENSIC ASPECT OF THE DEATH OF KING SEETHAWAKA RAJASINGHE

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ABSTRACT

Seethawaka kingdom existed for a relatively short period of 72 years, 1521-1593 AD. Mayadunne was the first king of Seethawaka and King Rajasinghe succeeded him in 1581. His sudden demise in 1592 is shrouded in mystery and speculations with some considering it to be a result of intentional poisoning. In this research, we investigate the information with regard to intentional harm, circumstances and cause of death.

Many primary sources of information including ola leaves dating back to the late 16th century were reviewed while many other secondary sources were also referred.

According to many sources King Rajasinghe sustained a bamboo thorn prick at Pethangoda on his return after a losing battle with King Vimaladharmasuriya I. Many historical accounts and a particular ola leaf letter indicate that a poisonous substance was applied on the king's wound. Recently a few researchers have put forward a theory that the king died of tetanus.

However, it is our view that tetanus is an unlikely condition in this situation. Presence of cyanide in the bamboo stem could have been the lethal substance.

It is also noted that constituents of the wound dressing are known to possess antimicrobial, antiseptic and many other medicinal properties.

The recent discovery of potent antibiotic in horse dung raises a question as to whether physicians in that era knew about the presence of such antimicrobial substance.

In conclusion it is our view that the king probably died of cyanide poisoning and alleged poisonous substances in fact may have been used as treatment in good faith.

INTRODUCTION

The Seethawaka kingdom existed for a relatively short period of 72 years (1521-1593 AD). The first king of Seethawaka was Mayadunne and in 1581 Prince Seethawaka Rajasinghe succeeded him. According to historians King Rajasinghe first took command of the Seethawaka forces at the age of 11 years. He fought many battles with Portuguese invaders during this period including the famous battle of Mulleriyawa until his untimely death in 1593. However, history reveals that his last battle was with King Vimaladharmasuriya I which he lost.

It is said that on his return after losing the battle with King Vimaladharmasuriya, at Pethangoda garden a bamboo thorn pierced his sole and he succumbed to its complications within a few days.[1,2] However, there are different speculations with regard to his death and one famous speculation is that the physician who treated him performed black magic and applied a wound dressing with contaminated substances.

The objective of this paper is to critically review facts regarding King Seethawaka Rajasinghe's death from a forensic viewpoint.

MATERIALS AND METHODS

Research on documentary evidence available on the said incident was carried out. In this regard Prof. Risiman Amarasinghe's research publication titled 'The Rise and Decline of the Kingdom of Sithawaka' was a valuable document.

Four primary documents were referred in reviewing facts regarding the king's death.

Following primary documents - *ola leaves* were referred.

i. King Seethawaka Rajasinghe's Birth document
ii. Seethawaka Rajasinghe Rajja Kale
iii. Maniayngama ola leaf
iv. Letter written by Shailendrasinghe the physician

Many other books and documents written by both local as well as international authors were referred to obtain more facts related to the death of the king.

CASE

Most common story about King Rajasinghe's death is that a bamboo thorn pierced his sole at Pethangoda garden. According to many sources it is said that '*Dodampe Ganithaya*' who treated the king, purposefully applied a dressing of contaminated material including cow-dung, horse-dung and athwagapul. Many believe that the king died of tetanus due to this act.[3,4]

Ellawala Medhananda thero in his article titled 'Historical and Archeological facts of Seethawaka era' states a different view about the death of the king. He refers to an unpublished document which is in his possession which says that King Seethawaka Rajasinghe was assaulted by the followers of prince Rajasuriya.

According to this article, a forceful blow was dealt to the leg for which *Dodampe Ganithaya* used his black magic and poisonous dressing to kill the king.[5]

Literature review shows that there are three possible explanations or speculations regarding king Rajasinghe's death. Apart from the above mentioned two methods there is another possible explanation given by some that he died following a snake bite.[6] There are many other sources which indicate different descriptions with regard to the time and place of death of King Seethawaka Rajasinghe.[7,8]

There are various documentary sources describing the survival period of the king following the injury but none provide an exact period of time.[8,9,10,11] However, according to the *ola leaf* letter written by *Shailendrasighe,* the king had died at the '20th jama' which is approximately 80 hours (4th day) after the injury.[12]

Prince Rajasuriya was said to have had an affair with the daughter of *Dodampe Ganithaya*. According to further information King Seethawaka Rajasinghe has taken this lady forcefully while she was bathing at a place now known as '*Bisowela*' and kept her as his 'queen' until her death. However, Amarasinghe in his thesis in 1998 raises doubts as to whether this Rajasuriya was a person other than prince Rajasuriya, King Seethawaka Rajasinghe's grandson.[6]

Other sources indicate that there were many people including persons in the hierarchy, such as Buddhist monks who were contemplating on ousting the king. In fact, it was some prominent Buddhist monks including Devanagala Rathanalankara thero and Gampola Rajaguru Dharmakeerthi thero who with some others in the hierarchy planned to oust Seethawaka Rajasinghe and make Konappu Bandara the king of Kandy.[10,13]

Facts

It is important to know some facts about the constituents of the dressing applied by '*Dodampe ganithaya'* and also about the plant called *kat una,* Tetanus etc.

Constituents of the dressing applied

Athwagapul:
Athwagapul is also known as *gajathippili* and *gajapeepal*.[14] This is a plant mainly found in India and also found along sub-Himalayan tract, Bengal, Orissa etc. The botanical name of this plant is *Scindapsus officinalis* which is said to possess many medicinal properties. It is a medicinal plant used in traditional Indian medicine. It is known to have antioxidant, anti-inflammatory, analgesic, anti-microbial and anti-viral properties.[15,16]

Cow dung:
According to Indian Ayurvedic medicine cow dung is an efficacious disinfectant and often used as fuel in lieu of firewood in India. Cow dung is also considered as an antiseptic. Not only is it free of bacteria but is also effective in killing it. Dried dung is odourless and produces slow even heat.[17]

Horse dung:
In contrast to cow dung this is known to contain several types of bacteria, fungi etc. However, in 2014 European scientists have discovered a very potent protein called copsin in horse dung which is considered to be resistant to heat, acid and other enzymes. It is also known to have a wide range of anti-bacterial activity which does not develop resistance easily.[18]

***Katu una* (*Bambusa arundinacea*):**
It is a medicinal plant used in traditional Indian medicine known to contain chemicals like hydrogen cyanide, benzoic acid etc. in its shoots. There are many other chemical derivatives in this plant, many of which after extraction are used in various illnesses and treatment methods.[19]

Copsin:
This is an antimicrobial peptide produced by a fungus called *Coprinopsis cinerea* and a natural substrate for this is dung of herbivores, especially of horses. This peptide has a wide range of anti-bacterial properties and also known to be heat resistant. [20,21]

Tetanus:
The muscular rigidity and spasms of tetanus are caused by tetanus toxin (tetanospasmin), which is produced by Clostridium tetani, an anaerobic bacillus, whose spores survive in soil and cause infection by contaminating wounds.

According to World Health Organization, the incubation period of tetanus is 3-21 days.[26] In general, the further the injury site is from the central nervous system, the longer is the incubation period. Shorter incubation periods are associated with a higher chance of death. In neonatal tetanus, symptoms usually appear from 4 to 14 days after birth, averaging about 7 days.[27]

Tetanus is a clinical diagnosis. Mere presence of the tetanus bacteria in the body or in the wound does not result in tetanus. According to research the tetanus bacteria is recovered in only 30% of cases. Even way back in 1920s it is recorded that though 20% of war wounds were contaminated with tetanus bacteria none of them showed any symptoms and signs of tetanus.[22]

Tetanus has four modes of clinical presentation: local, cephalic, generalized and neonatal. However local and cephalic tetanus is somewhat rare in occurrence than generalized tetanus.

A study in which the proportion dying of tetanus in relationship to probable entry site of the bacteria shows that the lowest death rate is associated with the entry site being the foot of the victim.[23]

DISCUSSION

The facts regarding this case will analyzed under following topics;

1. Were there people who wanted to oust the king?
2. Is intentional poisoning possible?
3. If it was done how effective is that method in 'killing' the king?
4. Is it possible that Rajasinghe died of tetanus?
5. Are there any other explanation for these events?

According to Amarasinghe there are many sources to indicate that in fact there was a movement to oust King Rajasinghe. In the context of practices that existed during this period 'ousting a king' is almost synonymous with 'killing of the king'.

History reveals that the Portuguese, who were confined to Colombo fort due to the efforts of Rajasinghe harboured a grudge against Rajasinghe. One historical source even indicates an unsuccessfully attempted by the Portuguese to poison him on an earlier occasion.[8] In the Kandyan kingdom also there were many waiting to oust Rajasinghe especially people like Konappu Bandara who was later crowned as Vimaladharmasuriya I and his allies etc. Consequently, it may be concluded that there were many who were looking for an opportunity to kill the king.

Under these circumstances it maybe speculated that any of these people would take the first opportunity to kill the king, especially when he is injured and immobile. Poisoning would be an ideal method to kill someone as it would not leave any tell-tale evidence of any interference, outwardly. Considering the events which occurred after the king was injured would also seem to be very conducive to killing of the king.

Many historical sources say that the wound was applied with poisonous substance by *Dodampe Ganithaya*.[6,13] Historians usually give more weightage for a fact when similar description is given in multiple sources. This is especially true if any of these documents have been written during the same period or era. Presence of circumstantial evidence on an event does further increases the significance of an event.

In this particular incident as many sources state the application of poisonous substance (*visa bandaweema*) and letter implicating a particular person - *Don Peduru* applying this on the king's wound under the influence of certain other people, almost confirms the intention to kill the king.[6,10,12] However, most of the sources implicate that this was done by *Dodampe Ganithaya* who was brought to treat the king. But contradicting evidence in *Shailendrasinghe's* letter implicates another person. This creates doubt as to the identity of the perpetrator. There is also a possibility of both these persons being one and the same. There is no definitive description about '*Don Peduru*' anywhere else in other sources. This raises the issue of determining culpability of intentional poisoning on a particular person.

Veerasingam in his article published in 2002 interpret the signs and symptoms demonstrated by King Rajasinghe as being due to tetanus.[3] He discusses the symptom and signs in its chronological appearance and shows how it corresponds to tetanus. Gunathilake in his article in 2007 agrees with Veerasingam and describes the events and confirms the symptoms and signs to be of tetanus.[3,6] In an article written to Sunday Lakbima, Dannister Perera analyzing the facts stated by Gunathilake agrees with him although he has raised some concerns about the time *Shailendrasinghe's* letter was written.

One important aspect that needs to be considered is the exact method of causation of injury to King Rajasinghe. This aspect has been analyzed by Amarasinghe in his thesis in 1998.[6]

According to him the most likely method of injury is accidental prick with a bamboo thorn. The speculation of snake bite has to be discarded since there are no reports of such an incident in the literature and according to Amarasinghe it is a folklore existing in the area around Pethangoda. The second speculation of assault to the sole or leg of the king by his enemies also seems to be very unlikely.[6] Anyone who wanted to harm or kill the king would not have considered assaulting him on the leg as it is very unlikely to result in severe injury or death. However, there is one important point mentioned by Dannister Perera in his article, that is there are 107 fatal points in the body ('*marmasthana*') according to Ayurveda and one of these is said to be in the anterior part of the sole which is named as '*thalahrudaya*'.[26] Mandarampura Puwatha in its contents mentions that king Rajasinghe was wearing shoes ('*Miriwedi*) at the time of injury.[27] In this context it is very unlikely or even impossible for someone to inflict a deadly blow to the sole involving the '*marmasthanaya*' called '*thalahrudaya*'. Therefore, it can be safely concluded that intentional trauma to the foot/leg of the king is unlikely.

According to another historical document King Rajasinghe fell from the horse in to a pool of mud at Pethangoda where a bamboo thorn pricked his right sole.[10] Analysis of this information indicates that infliction of trauma to the foot of the king is an accident.

Many sources indicate intentional poisoning of the wound. In a forensic point of view if someone is contemplating to kill another especially a person higher in the hierarchy, he or she would use a method that is sure to kill the victim. Applying a dressing with contaminated material with the expectation that it would cause tetanus is unlikely. In the past when someone becomes the king by killing his predecessor it is usually never questioned. Therefore, killing the wounded king with even an obvious method is not that uncommon.

According to Veerasingam, signs and symptoms mentioned in the ola leaf letter written by *Shailendrasinghe* corresponds to those of tetanus. He gives the signs and symptoms developed by the king in a table with the corresponding timing of appearance.[3] However some symptoms are misinterpreted according to our view. For example, the term '*Wakkutuweema*' mentioned in Shilendrasinghe's letter has been considered as opisthotonos. However according to Ayurveda *wakkutuweema* is flexion of the body and therefore cannot be considered as opisthotonos.

In accordance with the information obtain from various sources King Rajasinghe has died on the fourth day after thorn prick.[6] according to *Shilendrasinghe* king has developed symptoms at the beginning of 8th Jama (32 Hours), which means on the 2nd day. Since the incubation period of tetanus is 3-21 days and the injury being in the sole makes it unlikely to be tetanus. Consideration of these facts indicate that the occurrence of tetanus in this situation is doubtful.

Next, for consideration are the effects of thorn prick injury. '*Katu una*' is a plant indigenous to India and a few countries in the Indian subcontinent bearing the botanical name *Bambusa arundinacea*. It contains a wide range of chemical substances and importantly hydrogen cyanide (HCN) in the stem.[28] According to an analysis done in India young shoots contain 0.03% HCN and ingestion of eight grams of raw shoots or slightly more improperly cooked shoots can cause death.[29] Young shoot emerges from the ground which is of a conical shape. As it emerges from the ground the end of it could be pointed enough to cause injury especially if a person falls on to it.

HCN is a potent cytotoxic which could cause rapid symptoms and death depending on the amount of poison entering the body. HCN poisoning is known to cause symptoms and signs like headache, tightening sensation of the throat, vomiting to shortness of breath, seizures confusion etc.

What other evidence is there to suggest HCN poisoning rather than occurrence of tetanus in this case? Various sources of literature indicate that the King died on the fourth day after the thorn prick.[12,13] This makes it unlikely to be tetanus as the usual incubation period of tetanus is 3-21 days.

Considering the constituents of the dressing applied to the wound *athwagapul* which is also known as *gaja thippili* in Ayurvedic medicine is a medicinal plant.[14,15,16]

Next, we like to analyze the implications of the dressing applied to the wound. According to *Shailendrasinghe*'s letter it contained of horse-dung, cow-dung and *athwagapul*. *Athwagapul* which is also known as *gaja thippili* in Ayurvedic medicine is a medicinal plant.[14,15,16] It is also known to cause dehydrating effect on tissues.[15,16] Therefore, it is very likely that it had been used for its medicinal properties to relieve pain, inflammation etc. Cow-dung according to Indian Ayurvedic practice is a sterile substance. In addition, they consider it to possess antiseptic effects as well.[17] In contrast to cow-dung, horse-dung is known to contain a wide range of bacteria and fungi. Could it be the substance which caused lethal complications? Scientists have discovered a fungus called *Coprinopsis cinerea* that grows in horse dung which produces a protein called 'copsin' which is known to have very potent broad spectrum anti-microbial properties. *Shailendrasinghe* in his letter about application of this dressing says '*thalathelin kakara*' is heating and stirring till most of the water evaporates while Veerasingam suggests that this was done to kill bacteria other than the tetanus bacteria which is supposed to be heat resistant.[13] However, this is not a very practical way of killing other organisms leaving only tetanus spores. On the other hand, it could have been done to kill all other organisms and keep the copsin remaining in the substance so that it could exert its antibacterial properties more effectively.

CONCLUSIONS

To use a method expected to cause tetanus and death is an unlikely to be used to kill a person. It is far easier to use a known potent poison for this purpose. Furthermore, mere introduction of spore bearing tetanus bacteria will not always result in tetanus.

Therefore, we conclude that use of contaminated material to dress the wound to cause tetanus is an unlikely method if the intention was to kill King Seethawaka Rajasinghe.

Furthermore, considering the rapid onset of symptoms and death make tetanus unlikely. In our opinion, death would have resulted due to hydrogen cyanide poisoning by bamboo thorn prick. It is very likely that whoever dressed the wound did it in good faith. Considering this evidence, we conclude that the possible circumstance of death would be accidental and not homicidal.

We do not intend to discard the possibility of tetanus as a cause of death in this case but analysis of the facts and evidence makes hydrogen cyanide (HCN) poisoning more possible than tetanus.

However, since this is an analysis historical data and facts stated by different individuals both medical and non-medical it is almost impossible to arrive at a definite and accurate conclusion about circumstances of death or the cause of death.

ETHICAL ISSUES

None

CONFLICTS OF INTEREST

There are no conflicts of interest

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AUTHOR CONTRIBUTIONS

NDNAM: Perusal of documents and writing the article**; RARPS:** Perusal of documents, providing facts on Ayurvedic medicine and editing the article.

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