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EDITORIAL

# Rank and impact of forensic journals – Where do we stand?

**Tanuj Kanchan**

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Researchers are constantly looking for best journals to publish their work. In this regard, a need for selecting highly placed specialty journals has been emphasized.[1] Researchers should look for indexing status, Journal Impact Factor (JIF), and journal rankings etc. for publishing their work. The task however, is not straightforward, considering the existence of innumerable indexing agencies, ranking systems, to impact factors derived by journals to showcase their impact attract the researchers. It needs to be emphasized here that Web of Science (WoS) and Scopus databases are the preferred and widely recognized abstracting/ indexing agencies that researchers should look forward to, while selecting a suitable journal for publication of their work. Likewise, the only accepted impact factor is JIF, that is given for the journals included in Web of Science Master Journal List (WoS MJL), which includes 11,877 journals.

In our endeavor to present the leading forensic journals; the Journal Citation Reports® (JCR) published by Clarivate Analytics (Web of Science source data),[2] and Scimago Journal & Country Rank (SJR)[3] by Scopus® were searched for in the category Medicine, Legal, and Pathology and Forensic Medicine respectively. Besides, keywords 'forensic', and 'medicolegal' were also used to extend the search. The top ranked forensic journals in the Web of Science Master Journal List (Web of Science Core Collection: Science Citation Index Expanded) are shown in Table 1 along with their respective Scimago Journal & Country Rank (SJR), and abstracting and indexing in MEDLINE (PubMed). Barring a few exceptions as shown in Table 1, the journals listed in WoS appear in PubMed too. But its inverse may not necessarily occur, i.e. many journals in PubMed are not included in WoS. It is quite evident that none of the forensic medicine journals published from India, are included in either WoSMJL or MEDLINE/ PubMed. Forensic Medicine journals published from India, and listed in Scopus database are shown in Table 2. The Journal of Indian Academy of Forensic Medicine (JIAFM) appears at the top of this list. However, the SJR of forensic medicine journals published from India is notably lower than journals listed in Table 1.

**Table 2:** Forensic Medicine journals published from India and listed in Scopus (Details are based on SJR, 2018)

| Journal | SJR | h-index |
|---|---|---|
| Journal of Indian Academy of Forensic Medicine | 0.229 | 14 |
| Journal of Forensic Medicine and Toxicology | 0.155 | 18 |
| Journal of South India Medicolegal Association | 0.139 | 3 |
| Medico-Legal Update | 0.116 | 8 |
| Anil Aggarwal's Internet Journal of Forensic Medicine and Toxicology | 0.114 | 9 |
| Indian Journal of Forensic Medicine and Pathology | 0.110 | 1 |
| International Journal of Medical Toxicology and Legal Medicine | 0.101 | 8 |
| Journal of Punjab Academy of Forensic Medicine and Toxicology | 0.100 | 6 |

SJR – Scimago Journal & Country Rank (Powered by Scopus)

The article presents the list of top forensic journals and the standing of forensic medicine journals from India in global context. It is intended to guide researchers in their search for appropriate journals both for publishing their work as well as for the latest research and updates in our subject specialty. Besides, an overview to the widely recognized indexing agencies and JIF is likely to help researchers in identifying the genuine journals, their standing/ impact, and differentiating them from the predatory ones.

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3. Scimago Journal & Country Rank. Available at: https://www.scimagojr.com/journalrank.php

**Table 1:** Forensic journals published in Web of Science (WoS) Master Journal List (Details are based on JCR, 2018 and SJR, 2018)

| Journal | WoS MJL | | Scimago; Scopus | | Included in MEDLINE/ PubMed |
|---|---|---|---|---|---|
| | Rank | JIF | SJR | h-index | |
| Forensic Science International-Genetics | 1055 | 4.884 | 1.472 | 61 | Yes |
| Forensic Toxicology | 4037 | 2.476 | 1.071 | 30 | No |
| International Journal of Legal Medicine | 5066 | 2.094 | 0.900 | 75 | Yes |
| Forensic Science International | 5396 | 1.990 | 0.879 | 106 | Yes |
| Forensic Science Medicine and Pathology | 5993 | 1.815 | 0.545 | 30 | Yes |
| Science & Justice | 6480 | 1.675 | 0.816 | 39 | Yes |
| Australian Journal of Forensic Sciences | 7066 | 1.522 | 0.640 | 19 | No |
| Journal of Forensic Sciences | 7411 | 1.438 | 0.764 | 87 | Yes |
| Legal Medicine | 7573 | 1.404 | 0.720 | 39 | Yes |
| International Journal of Forensic Mental Health | 8129 | 1.271 | 0.630 | 32 | Yes |
| Journal of Forensic and Legal Medicine | 8468 | 1.199 | 0.615 | 40 | Yes |
| Journal of Forensic Psychiatry & Psychology | 9596 | 0.942 | 0.494 | 39 | No |
| Journal of Legal Medicine | 10359 | 0.769 | 0.308 | 17 | Yes |
| Journal of Law Medicine & Ethics | 10507 | 0.734 | 0.465 | 51 | Yes |
| Journal of Forensic Nursing | 10586 | 0.717 | 0.275 | 17 | Yes |
| American Journal of Forensic Medicine & Pathology | 11355 | 0.539 | 0.342 | 51 | Yes |
| Medicine Science and the Law | 11379 | 0.532 | 0.285 | 30 | Yes |
| Romanian Journal of Legal Medicine | 11589 | 0.480 | 0.244 | 11 | No |

JCR – Journal Citation Reports; JIF – Journal impact factor; WoS MJL – Web of Science Master Journal List; SJR – Scimago Journal & Country Rank (Powered by Scopus)

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ORIGINAL ARTICLE

# Determination of stature from female sternum in central Delhi population

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**Abstract**

Identification is one of the important aspects dealt with in forensic anthropology. It is necessary in cases of mass disasters or otherwise when no clue is present regarding the identity of individual. Bones have been used previously for identification by determining race, age, sex and stature. However, limited studies for estimation of stature from Sternal bone are available in literature. This study was conducted on a population of Delhi, India, to assess the usefulness of Sternal bone for determining stature. Results indicated that length of the Manubrium (R=0.631, SEE=5.67) is a useful parameter for stature estimation from female sternum while length of Mesosternum (R=0.0.098, SEE=7.28) and Sternal length (R=0.192, SEE=7.181) are not effective parameters. Regression equations were developed for each parameter. We also find that regression equations developed by researchers for other population samples are not useful for our population sample.

**Keywords**

Stature; Sternum; Female; Identification

## Introduction

Forensic anthropology involves the application of knowledge and techniques of physical anthropology to problems of medico-legal significance.[1] One such problem of significance is the identification of individuals. Skeletal remains are commonly used for identification as they resist putrefaction and destruction by animals. Estimation of Stature constitutes one of the traditional "big four" besides age, sex and ancestry.[2] Various researchers have identified and developed different methods for determination of stature from different bones. The most reliable long bone for estimating stature is the Femur.[3,4] Long bones and their fragments have been extensively studied for determining stature.[3-9] Since long bones are not always recovered, estimation of stature has been done using other bones like cranium, vertebra and bones of the hand and foot.[10-28]

Estimation of stature from the Sternum was, till recently, a neglected area with only Dwight[29] discussing the use of Sternum as an indicator for age, sex and height. Various reports have been published regarding determining age and sex from Sternal bone[29-36] However, interest in the potential use of the Sternum for determining stature is only recent. Different authors such as Menezes et al.[37,38] Singh et al.[39] Marinho et al.[40] Tumram et al.[41] Zhang et al.[42] Macaluso et al.[43] Yonguc[44] Chandrakant et al.[45] Gupta et al.[46] have studied the Sternum for determining stature. The skeletal characteristics vary with gender[10, 21, 28-36, 46] and region. Formulae developed in one region may not be acceptable for other regions. Hence, there is a need for studies to be conducted for each population group and for each gender, so that the developed formulae can be population specific and gender specific.

This study was undertaken with two aims. Firstly, to determine whether the Sternum is useful for estimating stature. If yes, then, to develop a regression equation that can be used for the population in Central Delhi, India. Secondly, to use the formulae developed by other researchers on our study sample to establish whether these formulae are population specific or not.

## Materials and Methods

The present study was conducted in the Department of Forensic Medicine, Maulana Azad Medical College, Delhi, India during the years 2007-2009. 34 intact female Sternum within age group of 25-85 years were dissected out by separating them from sternoclavicular joints and rib cage at costochondral junction. Bones that had been damaged or broken were excluded from study. These bones were labelled and buried in soil at a depth of about 1-2 feet for 6-8 weeks. They were subsequently retrieved, cleaned and labelled.

Measurements of Sternal bone were taken using manual vernier callipers using the technique described by Ashley.[47] Length of the Manubrium-M (straight distance from the deepest point of incisuria jugularis to the point on the lower margin of the Manubrium in the midsagital plane), Length of Mesosternum-B (straight distance from the lower margin of the Manubrium in the midsaggital plane to the deepest point on the lower margin of corpus sterni) and the Sternal Length- SL (Length from incisuria jugularis to the mesosterno-xiphoidal junction). The landmarks and measurements included in the study are shown in Fig.1. The measurements were initially recorded in millimetres and later converted to centimetres. Measurement of xiphoid process was not included because of the wide variations in length, appearance and ossification of xiphisternum.[48] Stature (S) of individuals was noted in centimetres to nearest 0.1cm using a measuring tape.[20]

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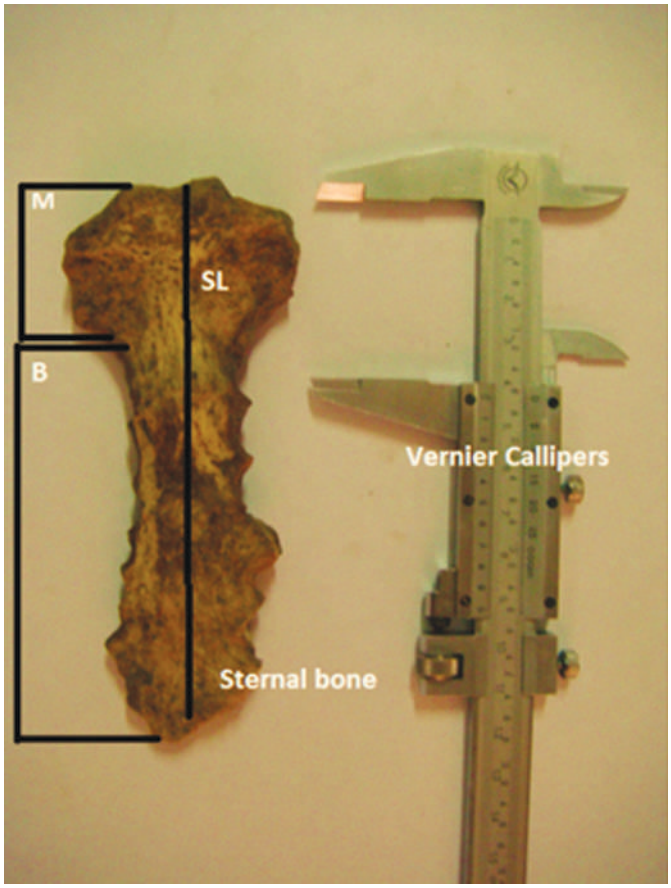


Data collected was analyzed using SPSS inc. version 16. Mean, Range and Standard Deviation of the measurements were calculated. The Stature of the individual (dependent variable) was regressed on the Length of Manubrium, length of Mesosternum and the Sternal length (independent variables) and linear regression equations were obtained. Correlation between Stature and these measurements was assessed using Pearsons correlations coefficient and its significance was tested using the student t test. A p-value of <0.01 was considered significant.

## Results

In the present study, the mean stature (+/- SD) of individuals varied from 150.32 (+/-7.20) cm with range of 25. The mean length of Manubrium (+/- SD) was 3.72(+/- 0.141) cm, mean length of Mesosternum (+/- SD) was 8.16(+/- 0.813) cm and mean Sternal length (+/- SD) was 11.88(+/- 0.88) cm. The regression equations derived by regressing stature of individual on length of Manubrium, length of Mesosternum and Sternal length were found to have a correlation coefficient of 0.631, 0.098 and 0.192 respectively and standard error of estimate of 5.67, 7.28 and 7.181 respectively. All these measurements were statistically highly significant. Based on these calculations, stature showed 39.8% variation with the length of the Manubrium, 1% variation with length of the Mesosternum and 3.7% variation with the Sternal length (Table 1 and Table 2).

**Table 1:** Descriptive statistics of Stature, Length of Manubrium, Length of Mesosternum and Sternal Length

| Variable | Mean | Minimum | Maximum | SD |
|---|---|---|---|---|
| Stature | 150.32 | 140 | 165 | 7.20 |
| M | 3.72 | 3.05 | 4.04 | 0.141 |
| B | 8.16 | 6.52 | 9.69 | 0.813 |
| SL | 11.88 | 10.0 | 13.54 | 0.88 |

M-Length of manubrium; B- Length of mesosternum; SL- Sternal length; SD- Standard deviation

**Table 2:** Regression analysis for estimation of stature

| Variable | Regression equations | R2 | R | SEE | P value |
|---|---|---|---|---|---|
| M | S = 30.445 + 32.151(M) | 0.398 | 0.631 | 5.67 | <0.001 |
| B | S = 143 + 0.868(B) | 0.01 | 0.098 | 7.28 | 0.582 |
| SL | S = 131.62 + 1.574(SL) | 0.037 | 0.192 | 7.181 | 0.277 |

M-Length of manubrium; B- Length of mesosternum; SL- Sternal length; SEE- Standard error of estimate

## Discussion

Identification is an integral part of any medico-legal investigation. In criminal as well as in civil matters identification is essential to meet ends of justice. Whether it is a mass disaster, flight accidents, railway accidents, bomb blasts or skeletal remains found at a place or simply when a patient is brought dead without any identifying documents on his person, the starting point for investigation in all cases is identification of the said individual.

**Table 3:** Comparison of observations of the present study with previous studies

| | Menezes et al[38] (n = 40) | Singh J et al[39] (n = 91) | Yonguc[44] (n = 30) | Chandrakant et al[45] (n = 50) | Present study (n = 34) |
|---|---|---|---|---|---|
| Study Population | Mangalore, South India | North-western, India | Turkey | Mysuru, South India | Delhi, North India |
| Range of stature | 146-168 | 136-177 | - | 140-181 | 140-165 |
| Mean stature (SD) | 155.88 (5.27) | 156 (6.98) | 160.2 (6.7) | 155.7 (8.1) | 150.32 (7.20) |
| Sternal Length (SL) | | | | | |
| Mean (SD) | 14.12 (1.07) | 14.3 91.245) | 17.92 (1.6) | 12.24 (1.62) | 11.88 (0.88) |
| Regression model | 111.59+3.316 (SL) | 130.82+0.18 (SL) | 110.783+0.27 (SL) | 140.315+0.167 (SL) | 131.62+1.574 (SL) |
| SEE | 4.11 | 6.66 | 0.059 | 9.26 | 7.181 |
| R | 0.639 | 0.317 | 0.662 | 0.259 | 0.192 |
| $R^2$ | – | 0.100 | 0.438 | 0.103 | 0.037 |
| Length of Manubrium (M) | | | | | |
| Mean (SD) | – | 4.72 (0.517) | 4.83 (0.54) | 4.37 (0.42) | 3.73 (0.141) |
| Regression model | – | 141.17+0.32 (M) | 120.276+0.827 (M) | 138.129+0.519 (M) | 30.445+32.15 (M) |
| SEE | – | 6.82 | 0.173 | 9.21 | 0.567 |
| R | – | 0.237 | 0.67 | 0.148 | 0.631 |
| $R^2$ | – | 0.06 | 0.448 | 0.144 | 0.398 |
| Length of Manubrium (B) | | | | | |
| Mean (SD) | – | 7.85 (1.023) | 9.71 (0.95) | 7.88 (1.43) | 8.16 (0.813) |
| Regression model | – | 144.02+ 0.16 (B) | 134.845+0.261 (B) | 150.126+0.143 (B) | 131.62+1.574 (B) |
| SEE | – | 6.83 | 0.123 | 9.51 | 7.28 |
| R | – | 0.229 | 0.372 | 0.243 | 0.098 |
| $R^2$ | – | 0.05 | 0.138 | 0.055 | 0.01 |

Role of the Sternum in identification has been largely limited to determination of age and sex from the bone. In the past, Menezes et al.[37,38] Singh J et al.[39] Yonguc et al.[44] Chandrakant et al. [45] have developed regression equations by regressing the stature of the individual on length of the female Sternum. All these researchers have conducted studies on dry macerated

sternum. Marinho et al.[40] and Tumram et al.[41] studied fresh Sternal bones in estimating stature. However, their studies did not include the female population. In the present study, the authors have studied the relation of Length of Manubrium, Mesosternum and the Sternal Length to the stature of the individual using dry sternal bones. In earlier studies, Singh et al.[39] Yonguc et al.[44] and Chandrakant et al.[45] studied and correlated all these parameters. Menezes et al.[37] have only studied the relation between Sternal length and stature. Observations in the present study have been compared with previous studies.

The range of stature of individuals in this present study was comparable to previous studies conducted by Menezes et al.[37] and Singh et al.[39] It was less when compared to the study done on a South Indian population by Chandrakant et al.[45] Mean length of Sternum in present study was less than the mean length of Sternum determined in all previous studies.[38, 39, 44, 45] Correlation coefficient for Sternal length and stature and additionally the variation of stature with Sternal length was lesser when compared to the previous studies.[38,39,44,45]

In the present study, mean length of Manubrium (+/- SD) was 3.73 (+/-0.141). This was less when compared to studies conducted by Singh et al.[39], Yonguc et al.[44] and Chandrakant et al.[45] Also the correlation coefficient and variance were found to be higher when compared to studies conducted by Singh et al.[39] and Chandrakant et al.[45] Correlation coefficient for the length of Mesosternum (0.098) and variance (0.01) were found to be significantly lower when compared to studies by Singh et al.[39] (0.229, 0.05), Yonguc et al.[44] (0.372, 0.138) and Chandrakant et al.[45] (0.243, 0.055). The mean length of Mesosternum was lower than obtained by Yonguc et al.[44] and higher than Singh J et al.[39] and Chandrakant et al.[45] In our study, Standard error of estimate (SEE) for sternal length was 7.181. This is comparable to the SEE reported by Singh et al.[39]

The regression equation derived by Menezes et al.[37] Singh et al.[39], Yonguc et al.[44] and Chandrakant et al.[45] for determining stature from Sternal length when applied to the data collected in present study, showed that in individual remains 04, 09, 21, and 34 out of the 66 remains, estimated stature was beyondthe 95% confidence interval. On applying the regression equations for length of Manubrium (M) derived by Singh et al.[39], Yonguc et al.[44] and Chandrakant et al.[45] for the present study, results showed that individuals 06, 25 and 34 lay beyond the 95% confidence interval. Similar results were seen for length of Mesosternum (B) on applying the regression equations derived by Singh et al.[39], Yonguc et al.[44] and Chandrakant et al.[45] for the present study, wherein individuals 15, 18 and 28 lay beyond the 95% confidence interval. However, statistically, these results show that equations derived by all these researchers for Sternal Length, length of Manubrium and length of Mesosternum cannot be used for Central Delhi Population.

Hence, as per our study, regression equations developed by Menezes et al.[37]Singh et al.[39]and Chandrakant et al.[45] (all for Indian population but in different regions) and Yonguc et al.[44] (Turkey population) could not provide an accurate estimate of stature for Central Delhi population. These findings emphasize that stature estimation is population specific and varies greatly with the population studied.

## Conclusions

In our study, the length of Manubrium correlated well with the stature of the female individual. The Sternal length and the length of Mesosternum were not found to be statistically relevant in determining stature from sternum in female population. Stature could be estimated using linear regression equations derived by regressing stature on these independent variables. Sternum may be considered for estimating stature if other bones like long bones, vertebral column, hand and foot bones are not available. Stature varies according to the population and region. Hence, formulae developed for one region may not be applicable for other regions. Regional studies should be conducted so that specific formulae may be derived for each population and gender.

**Ethical clearance:** A prior approval was obtained from the Institutional ethics committee

**Conflict of interest:** None to declare

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ORIGINAL ARTICLE

# Study of the pattern and injury severity score of fatal blunt abdominal injuries sustained in road traffic accident

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**Abstract**
Road traffic accident accounts for considerable morbidity and mortality all over the world. In this study out of the 98 cases of deaths due to road traffic accidents which were subjected to medico-legal autopsy, 50 cases (51.02%) had blunt abdominal injuries and 48 cases had combined thoraco-abdominal and other injuries sustained as a result of road traffic accidents. Among the intra-abdominal injuries in 34 (34.69%) cases laceration of the liver alone was responsible for the massive haemo-peritoneum, while in 28 (28.57%) of the cases there was combined laceration of both liver and spleen. Kidney laceration was found in 20(20.41%) of the cases. The commonest cause of death was found to be combined head injury and haemorrhagic shock (as a result of trauma leading to intra-abdominal bleeding due to laceration of the liver and spleen) constituting 62 cases (63.27%), and this was followed by 18 (18.36%) cases of death due to haemorrhagic shock. It was found that in victims of Road traffic accident (RTA) where Injury severity score (ISS) was low (21-30 and 31-40 ISS score ranges) survival duration was more as compared to the victims who had high ISS (51-60, 61-70 and 71-75 ISS score ranges) based on the severity of their injury.

**Keywords**
Road traffic accident; Thoraco-abdominal injuries; Autopsy

## Introduction

A motor vehicle accident is a situation where a motor vehicle collides with another vehicle, pedestrian, animal, road debris or any kind of stationary obstruction, such as a tree or pole. Such traffic collisions may result in injury, property damage and even loss of life. Data in 2013 from around the world shows that around 54 million people were involved in various form of road traffic accidents.[1] There are many causes of vehicular accidents and among them the most common causes are carelessness, violation of safe driving rules, and mechanical error of the vehicle. In a road traffic accident among all the vulnerable regions of the body abdomen is one important area and blunt trauma of the abdomen ranks as one of the leading causes of the mortality among trauma victims.[2] Blunt trauma of the abdomen can be very dangerous even without signs of any visible external injury and haemorrhage is the leading cause of preventable death after such trauma.[3] The abdominal region in human body is one of the highly vulnerable site due to the presence of very vital organs such as the liver, spleen, kidney, stomach and intestine, and hence injury to the abdomen can be potentially life threatening.[4] Many a times blunt trauma with resultant intra-abdominal haemorrhage is often overlooked and this possibility does not cross the minds of the emergency management team. Death following trauma after a road traffic accident depends on the severity of the trauma and the vital organs which are affected. Among the abdominal viscera liver and splenic laceration and consequent haemorrhage account for a vast majority of death. The two important reasons why the liver is one of the most frequently injured organs in a case of abdominal trauma are due to the anterior location of the liver and a highly fragile parenchyma with an equally fragile Glisson's capsule which tears easily and thus making this organ very much vulnerable.[5,6] The successful management of fatal abdominal injury producing traumatic haemorrhage is a very much complex multi disciplinary process. In most cases of poly trauma, a high index of suspicion is needed to document any intra-abdominal injury. This becomes increasingly important in view of the usual practice of over emphasis on other regions such as head, thorax and the extremities. Apart from clinical examination such as looking for vitals and signs of hemodynamic instability, imaging modalities form the most important diagnostic tool for finding liver and other intra-abdominal organ injury. The focused assessment by ultrasound for trauma is advocated for the initial evaluation of trauma.[7] However in developing countries like India still a lot need to be done to make procedures like focused assessment by ultrasound for trauma (FAST) and other high yield techniques such as CT scan part of standard diagnostic protocol in every case of RTA where chances of intra-abdominal injury are high. This study was done to identify and analyse the pattern of abdominal organ injuries which were sustained in road traffic accidents from the medico-legal autopsies conducted in the mortuary of a general hospital in Southern India. This study will be useful to identify the pattern of abdominal injuries sustained in RTAs and help in realization of importance of careful diagnostic emphasis to find out intra-abdominal trauma as early intervention can be lifesaving. It will also help to establish a relationship between the severity of injury and the chances of survival of victims of road traffic accident.

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## Materials and Methods

After obtaining approval of the institutional ethical committee, this cross-sectional observational autopsy-based study was done at Rajah Muthiah Institute of Health Sciences and general hospital Chidambaram, Tamil Nadu from the period of October 2014 to January 2016. During the period of the study a total of 140 cases of medico-legal autopsies were performed which included death due to various causes such as road traffic injuries, hanging, drowning, physical assault in homicide, poisoning etc and out these140 cases, 98 cases which were of road traffic accident with multi trauma, were examined to look for the presence of fatal intra-abdominal injuries. The inclusion criteria included those cases of road traffic accident which showed presence of multi trauma including abdominal injuries. However, those cases where the bodies were decomposed and the cause of trauma was ambiguous were excluded from the study. The severity and rate of injuries were calculated and predicted using the ISS (injury severity score) which is an anatomical scoring system, and AIS (abbreviated injury scale). Accordingly, each injury has been assigned an AIS score and is allocated to six anatomical regions such as head, face, chest, abdomen, extremities (including pelvis). To predict the ISS only the highest AIS score in each body region is used. The 3 most severely injured body regions have their score squared and added together to produce the ISS which ranged from 1 to 75. In a victim who had an injury with an AIS value of 6, the ISS was assigned a value of 75.

A pretested autopsy proforma was developed to systematically collect the relevant data during medico-legal post-mortem examination of deaths due to RTA. The data was collected from the investigating police officer who accompanied the body of the deceased to the mortuary, from relevant documents such as the inquest report etc which were submitted by the police before autopsy examination, information from the relatives, friends and others who were accompanying the body, and autopsy observations. In case the deceased was hospitalized following the accident then medical history including treatment related facts was studied. Following collection of all the data they were recorded and subsequently were statistically analysed using SPSS 20 software.

## Results

Out of the 98 cases of medico-legal autopsies conducted on victims of road traffic accident between the period of October 2014 to January 2016, 50 cases (51.02%) had mainly blunt abdominal injuries whereas 48 cases had combined thoraco-abdominal and other multiple injuries sustained as a result of road traffic accident. Males comprised majority with 68 cases (69.38%) of the total cases with a male to female ratio of 5:1. The most common age group between 30-40 years comprised 40 cases (40.82%) and this was followed by 21-30 years with 28 cases (28.57 %) the cases respectively (Table 1).

The most common victims were two-wheeler riders with 52 cases (53.06%) and this was followed by pedestrians with 33 cases (33.68%) and four-wheeler accidents accounted for 13 cases (13.26%) as shown in Table 2.

**Table 1:** Age and sex distribution

| Age Group | Males N(%) | Females N(%) | Total (%) |
|---|---|---|---|
| 0-11 years1 | 2 (2.04) | ..... | 2 (2.04) |
| 1-20 years | 4 (4.08) | 3 (3.06) | 7(7.04) |
| 21-30 years | 17(17.34) | 11 (11.22) | 28 (28.45) |
| 31-40 years | 22(22.45) | 18 (18.37) | 40 (40.82) |
| 41-50 years | 8 (8.17) | 5 (5.11) | 13 (13.27) |
| 51-60 years | 5 (5.11) | 3 (3.06) | 8 (8.16) |
| Total | 58 (100.00) | 40 (100.00) | 98 (100.00) |

**Table 2:** Victims of road traffic accident

| Victims | N | (%) |
|---|---|---|
| Two wheeler riders: | 52 | 53.06 |
| a) Bi-Cyclist | 13 | |
| b) Motorbike riders | 22 | |
| c) Pillion riders | 17 | |
| Pedestrian | 33 | 33.67 |
| Four wheeler riders | 13 | 13.6 |
| a) Driver | 5 | |
| b) Front seat occupant | 6 | |
| c) Rear seat occupant | 2 | |
| Total | 98 | 100 |

The most common offending vehicle was heavy motor vehicles with 42 (42.85%) cases but however in 16 cases the two-wheeler riders met accident due to presence of potholes on the road. In this present study 38 cases had intra-abdominal injury (38.77%), 26 (26.53%) cases had combined thoraco-abdominal injury and 34 (34.69%) of the victims had multiple injuries including thoraco-abdominal and head injury as depicted in Table 3.

**Table 3:** Injury pattern

| Injury pattern | N | (%) |
|---|---|---|
| Abdominal Injury | 38 | 38.77 |
| Thoraco-abdominal | 16 | 26.53 |
| Multiple (Abdominal, thoraco-abdominal, Head) | 34 | 34.69 |
| Total | 98 | 100.00 |

Of the total cases only 12 of the cases had visible external injuries over the abdominal region while the remaining showing no signs of any external injury over the abdominal area. However, the presence of external injuries on limbs, face in the form of abrasion, laceration and contusions was noted in all the cases. Among the external injuries noted over the abdominal area, the most common type of injury was contusions (n=4) followed by abrasion (n=8). Among the intra-abdominal injuries, in 34 (34.69%) cases laceration of the liver alone was responsible for the massive haemo-peritoneum, while in 28 (28.57%) of the cases there was combined laceration of both liver and spleen. Kidney laceration together with laceration liver and spleen was found in 20 (20.41%) of the cases as shown in Table 4.

The commonest cause of death was found to be combined head injury and haemorrhagic shock (as a result of accompanying intra-

**Table 4:** Involvement of intra –abdominal organs

| Intra-abdominal injury | N | (%) |
|---|---|---|
| Liver | 34 | 34.69 |
| Spleen+liver | 28 | 28.57 |
| Kidney+ Spleen+ Liver | 20 | 20.41 |
| Stoamch, Pancreas | 12 | 12.24 |
| Diaphragm, Gall bladder, mesentery | 4 | 4.08 |
| Total | 98 | 100.00 |

abdominal trauma leading to laceration of the liver and spleen trauma) constituting 62 cases (63.27%), and this was followed by 18 (18.36%) cases of death due to haemorrhagic shock, and cardiac tamponade was the responsible for death in 8 cases (8.17%). 7 (7.14%) victims died due to combined head injury and peritonitis and peritonitis alone caused death in 3 (3.06%) cases as shown in Table 5.

**Table 5:** Cause of death

| Cause of death | N | (%) |
|---|---|---|
| Hemorrhagic shock+ Head injury | 62 | 34.69 |
| Hemorrhagic shock + Intra- abdominal organ injury | 18 | 28.57 |
| Cardiac tamponade | 8 | 20.41 |
| Head injury+ peritonitis | 7 | 12.24 |
| Pertonitis | 3 | 4.08 |
| Total | 98 | 100.00 |

The majority of the victims had died at the spot of accident (57.14%, n=56), followed by 6 victims (6.12%) who died on the way to hospital in less than 1 hour (Table 6). It was found that in victims of RTA where ISS was low (21-30 and 31-40 ISS score ranges) survival duration was more as compared to the victims who had high ISS (in the range of 51-60, 61-70 and 71-75 ISS score) based on the severity of their injury. The majority of the victims in this study who died at the spot of the accident had very high injury severity score in the range of 61-70 (n=21) and 71-75 (n=24) respectively as shown in Table 6.

**Table 6:** Relation between survival and injury severity score

| Survival ISS | Nil (N=56) | >1hr (N=6) | >2-6 hr (N-16) | >6-12hr (N=5) | >12-24hr (N=9) | >1-7days (N=2) | >2Wk (N=4) |
|---|---|---|---|---|---|---|---|
| 0-10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21-30 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| 31-40 | 1 | 0 | 2 | 1 | 2 | 0 | 1 |
| 41-50 | 5 | 1 | 3 | 1 | 0 | 1 | 1 |
| 51-60 | 4 | 1 | 6 | 3 | 3 | 0 | 2 |
| 61-70 | 21 | 2 | 3 | 0 | 4 | 1 | 0 |
| 75 | 24 | 2 | 0 | 0 | 0 | 0 | 0 |

## Discussion

Road traffic accident (RTA) accounts for significant number of morbidity and mortality and this is true for both developed and as well as developing countries. The increasing population coupled together with the increased migration of people from rural to urban areas and increasing number of vehicles and bad road conditions contributes towards the growing number of vehicular accidents in India. In this study death due to RTA accounted for the 98 cases out of the total 140 cases of autopsy and this is in agreement with the findings of previous workers.[8,9] In this study the majority of the victims were two wheeler occupants followed by pedestrians and this was different from the findings of other workers[10] but however is in agreement with the findings of other workers.[11,12]

The increased number of abdominal injuries as was observed in this study differs from the work of other authors who found thoracic and thoraco-abdominal to constitute the most common type among the victims of RTA.[9,12] In the present study male to female ratio was 5:1 and the majority of victims were between the age group of 21-30 and 31-40 years and this is in accordance with other workers.[9,12-14] This increased number of male victims could be due to the fact that most males compared to females work outdoors and are hence more vulnerable to have accidents.

The most common offending vehicle was heavy motor vehicles (42.85%) and this was similar to the observation made in previous studies.[11,14,15] This is probably due to the rash and negligent driving, less regard for road safety regulation and poor road conditions. Another finding in this study was that two-wheeler riders meet accidents during rainy seasons where the rider could not identify the big water logged potholes on the road and after their bike fell in the pothole, they sustained serious injuries and died. This is a very pathetic finding where due to civic apathy the road conditions remain in deplorable state resulting in considerable loss of life. In this study most victims had abdominal injury followed by combined thoraco-abdominal injuries and of those having abdominal injury there was also presence of external injuries over the abdomen and this was not similar to the finding of earlier workers[9,10,13,16] who did not find any visible external injury over the abdomen in most cases of blunt trauma of abdomen. The most commonly involved intra-abdominal organ was both liver and spleen with 52 cases, whereas only liver injury accounting for 25 cases and kidney injury 21 cases. This finding is slightly different from the work of Kanchan et al.[17] who found kidneys to be the most commonly involved intra-abdominal organ in blunt trauma following RTA. This increased injury involving both liver and spleen could be attributed to the superficial location of both these solid organs and liver being a large organ is prone to undergo laceration following blunt trauma abdomen and more so in road traffic accidents.

The majority of the victims died due to combination of haemorrhage and shock resulting from fatal trauma of thorax, abdomen and head and this in concordance with the findings of Meera.[18] In cases of road traffic accidents even though head injury has been the most common cause of morbidity and mortality, however in this study abdominal injury was observed in the majority of cases at autopsy and this could be explained by the fact that more motorists are now using helmets and traditionally after hospitalization following the accident much emphasis used to be given looking for head trauma and external injuries such as fractures and other mechanical injures such as laceration, contusion etc.

However, abdominal region which is highly vulnerable and frequently undergoes serious life-threatening injuries is often neglected. Even though patient does not have apparently much serious external injury and head injury also ruled out sometimes patient develops hemodynamic deterioration due to internal haemorrhage and dies and at autopsy when the abdominal cavity used to be opened there used to be collected of blood in the peritoneum and vital abdominal organs like liver, spleen and kidneys are found lacerated. Most of the victims had died on the spot of the accident and the diagnosis of fatal injuries was confirmed at autopsy and this shows the severity of the accidents and also the fact that roadside emergency management and transportation delay are big reasons behind increased fatality. This is in disagreement with the findings of other authors[17] but was similar to the observation of Daly K.E. and Thomas P.R.[19] The survival duration in cases of fatal RTA depends upon the severity of injuries and those cases with high ISS have very poor changes of survival and this is agreement with the findings of other workers who too had found that victims with high ISS died on the spot.[18, 20] In this study victims who had high injury severity score had high mortality and this is due to the severity of the injuries which were so severe that they were untreatable and victims condition was not survivable. The high number of case fatalities where death of the victim occurred on the spot of the accident, points to the critical state of the injuries sustained and also explains the relation between severity of injury and the period of survival following the accident.

## Conclusions

Road traffic accidents are a significant cause of morbidity and mortality worldwide. The burden of road traffic accidents is very high and among the developing countries India faces a big problem due to road traffic accidents which is a major cause of loss of so many lives every year. This study has tried to look into the pattern of abdominal injuries which are sustained in victims of RTA who have had other polytrauma following the accident. The abdominal region of the body with very vital and vulnerable organs is unfortunately often overlooked and due to this intrabdominal organ injury and resultant haemorrhage claims many lives. Traditionally much emphasis has been given to head, thorax and extremity injuries but abdominal region also needs to be carefully looked into. This study has tried to focus on the importance of the involvement of abdominal region in cases of RTAs, and the findings of this study could be used to do such similar studies on a larger scale to find out a larger state wise or nation wise data about intra-abdominal injury sustained in case of RTAs. One of the major limitations of this study was that it was done only at particular centre and there is a need to have similar studies at different centres of India to collect and maintain much larger database involving different districts, and states of India to compare with the scenario existing among the various states and union territories of India and also with other developing nations of the world.

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ORIGINAL ARTICLE

# Pattern of homicidal deaths autopsied at Victoria Hospital, Bangalore – A one-year study

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**Abstract**

Homicide is the outrageous and the severest form of violent crime, where one human being divests another human being of the fundamental right to live. The rate of homicidal deaths is considered the most representative crime indicator. The present study attempts to analyze the recent trend of the homicidal deaths and it's demographic, social and medico-legal aspects in one of the major cities of Karnataka state. The study was carried out for 1 year (2017) in the Department of Forensic Medicine, tertiary care hospital attached to a medical college. The cases brought to the department for medico-legal autopsy either confirmed or later registered as homicide by investigating police officer were considered for the study. Homicidal deaths constituted 2.2% of the total autopsies done where the majority of victims belonged to 3rd and 4th decades of life with male predomination in all age groups except for 1st decade. Maximum victims were assassinated at the street during the afternoon and late evening. The main motive was revenge in 89.5% of cases. Sharp weapon injuries (38%) were the commonest pattern of death followed by blunt weapon injuries (25%).

**Keywords**

Homicide; Victims; Assassinated; Sharp/blunt weapons; Revenge; Bangalore

## Introduction

Homicide is the outrageous and the severest form of violent crime, where one human being divests another human being of the fundamental right to live. Homicide is defined legally as the destruction of human life by the act, agencies, procurement or culpable omission of some other person or persons.[1] Such activities distort peace and consonance in society and ingrain a sense of insecurity and fear in the community. It represents one of the leading causes of death caused by expression of aggression in its most extreme form.[2] It constitutes two elements; *Mens rea* which means preplanning or aforethought and *Actus reus* which means the actual execution.

Though homicide is present right from the time of old civilization, the motives have seemed to be changing. It is more common in countries with high levels of income inequality than in more equitable societies, where socio-economic stability seems to function as an antidote to homicide[3] Many factors influence such behavior like stresses faced in life due to financial, emotional and health issues, the negative influence of media and movies etc. Improvisation and sophistication of weapon of violence as well as its easy availability, cosmopolitism of urban areas, propagation of religious hatred feelings and terrorism may also be the factors that attribute to the increasing incidence of homicidal deaths. Murder seemingly is not biased with Bangalore. The city's pride as a paradise once earned through peace has been turned heads down due to rampant rise in murders every day.

Homicide can be considered the 'tip of the violence iceberg' as all kinds of other violent crimes are not been recorded by the system. The rate of homicidal deaths is considered the most representative crime indicator. Hence, this study attempts to analyze the recent trend of the homicidal deaths and it's demographic, social and medico-legal aspects in one of the major cities of Karnataka state. The aims and objectives of the present study were to find out the most susceptible age group, sex incidence, motive, and pattern of homicide, place and time of occurrence of crime, and throw light on cases which were initially alleged to be suicidal, accidental or natural deaths but later registered as homicidal deaths by autopsy report and police investigation during the study period.

## Materials and Methods

The present study was conducted in the Department of Forensic Medicine at a tertiary care hospital attached to the medical college. The study is a prospective study done for a duration of one year (2017). Institutional ethical clearance was obtained prior to conducting the study. All types of murder cases described in Section 302 of IPC were included in this study. The cases brought to the Department for medico-legal autopsy either confirmed or later registered as homicide by investigating police officer were considered for the study. Any cases subjected for autopsy with an alleged or suspected history of homicide but which were later registered as non-homicidal based on the autopsy findings, circumstantial evidence and investigation by the police and any cases where data was incomplete were excluded. The autopsy cases conducted at hospital includes cases from the south zone, south-east zone, east zone and part of the central zone of the city as well as the

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referral cases from the rural region of the city as well. The detailed information regarding the circumstances of crime was sought from the police, victim's relatives and friends, visit to the scene of occurrence or concluded by the photographs of the scene of occurrence. The data obtained is in the form of percentages, analyzed using descriptive statistics.

## Results

Total number of cases autopsied in the year 2017 was 3185. Death due to homicide was 71 (2.2%). Our study exhibits a preponderance of male (81.6%) over female victims (18.3%). The majority of the victims belonged to age group 30-39 years 24 cases (33.8%) followed by 20-29 years' age group with 21 cases (29.5%) as shown in Table 1.

**Table 1:** Distribution of victims based on age and sex

| Age Group | Males | Females |
|---|---|---|
| 0 to 9 | 01 | 03 |
| 10 to 19 | 04 | 0 |
| 20 to 29 | 17 | 04 |
| 30 to 39 | 20 | 04 |
| 40 to 49 | 08 | 01 |
| 50 to 59 | 04 | 01 |
| ≥60 | 04 | 0 |
| Total | 58 | 13 |

Most of the cases (97.1%) were brought to the department with alleged history as homicidal deaths while 1 case was alleged to be an accidental death and another as natural death (Table 2).

**Table 2:** Distribution of manner of death according to alleged history

| Alleged history | N (%) |
|---|---|
| Homicidal death | 69(97.1%) |
| Accidental death | 01(1.4%) |
| Natural death | 01(1.4%) |
| Total | 71(100%) |

Revenge was the motive for killing in the majority of the cases (85.9%) followed by arguments, financial conflicts and infidelity (Table 3).

**Table 3:** Distribution of homicide based on motive

| Motive | N (%) |
|---|---|
| Argument | 04(5.6%) |
| Infidelity | 02(2.8%) |
| Revenge | 61(85.9%) |
| Property | 01(1.4%) |
| Financial conflicts | 03(4.2%) |
| Total | 71(100%) |

Maximum number of victims were killed at street/road (73.2%) followed by hotel/bar/restaurant (14%) as shown in Table 4.

Distribution of homicidal deaths according to the time of occurrence is depicted in Table 5.

The majority of the homicidal offenses occurred in the urban region (63.3%) of the city followed by rural areas (29.5%). In 27 cases (38%), only sharp cutting weapons while in 18 cases (25%) only hard and blunt weapons were used to inflict injuries. The firearm was used in 1 case and homicidal burns were reported in 4 cases. Homicidal asphyxiation was found in 11.25% of the victims (Table 6).

**Table 4:** Distribution of place of occurrence

| Place of occurrence | N (%) |
|---|---|
| Street/Road | 52(73.2%) |
| Victim's residence | 03(4.2%) |
| Hotel /Bar/Restaurant | 10(14%) |
| Others | 06(8.4%) |
| Total | 71(100%) |

**Table 5:** Distribution of homicides according to Time of Occurrence

| Time of Occurrence | N(%) |
|---|---|
| Morning ( 6am-12pm) | 20(28%) |
| Afternoon (12pm-6pm) | 24(33.8%) |
| Evening (6pm-12am) | 23(32.35) |
| Late night (12am-6am) | 04(5.6%) |
| Total | 71(100%) |

**Table 6:** Distribution of cases according to pattern of injury

| Pattern of Death | N(%) |
|---|---|
| Sharp weapon injuries | 27(38%) |
| Blunt weapon injuries | 18(25%) |
| Sharp and blunt weapon injuries | 10(14%) |
| Firearm | 01(1.4%) |
| Asphyxial deaths | 08(11.2%) |
| a) Ligature strangulation | 04 |
| b) Manual strangulation | 01 |
| c) Smothering | 02 |
| d) Drowning | 01 |
| Flame burns | 04(5.6%) |
| Poisoning | 02(2.8%) |
| History of natural death | 01(1.4%) |
| Total | 71(100%) |

## Discussion

Homicidal crimes are one of the most common offences in the present time of urbanization and industrialization. Financial conflicts, infidelity, poverty, stress, lack of proper educational and recreational facilities, migratory population, and easy accessibility to addictive drugs and weapons of violence, poor temperament, unemployment, substance abuse etc. are some instigating circumstances for such kind of violent offenses.

Our study showed an overall percentage of homicide cases to be 2.2% out of all medico-legal autopsies conducted. These results are lower than Global homicide rate i.e. 6.9% and a homicide rate of Asia, Europe, and America which is 3%, 4%, and 16% respectively.[3] These findings are also lower than the earlier observations made by Sheikh,[4] Prajapati et al.,[5] and Basappa et al.,[6] but far less than that of Chhattisgarh- 9.13%as seen in the study by Patel et al.[7] The present study holds up the fact that homicidal crimes have decreased recently which correlates with the global trend.

Our study exhibits a preponderance of male victims (81.6%) over female victims (18.3%) with a male to female ratio of 4.46:1 which may be attributed to aggressive nature, involvement in more outdoor activities, indulging in violent behavior and their risk-taking behavior in the male gender. The lower incidence in females may be due to custom, social values and preference of females to stay indoors. These results are higher than observations made by Basappa et al.,[6] Parmar et al.,[8] and Ghambhir et al.[9] while it is in clear contrast with the study of Kominato et al.[10] where male: female ratio was of 1: 1.

Majority of the victims belonged to age group 30-39 years - 24 cases (33.8%) followed by 20-29 years age group with 21 cases (29.5%) which together comprises 63.3% of the total victims. The age group (21-39) in the present day and age comprises of highly competitive and ambitious ones, who have on their shoulders responsibility of earning and getting married and settling down by the age of 40 due to societal pressures. This makes them more frustrated and vulnerable to violence. Male victims predominated in all age groups except for 0 to 9 years, where female victims were more prevalent, showing that the society is still unable to ensure the safety of young females. Our results regarding age distribution are in accordance with that of Wahlstenet al.[11] where most of the victims belonged to 31-40 years but in contrast with study of Kominato[10] where victims belonged to 36-45 years and Basappa et al[6] where they belonged to 21-29 years.

Most of the cases - 69 (97.1%) were brought to the Department with alleged history of homicidal deaths. One case was alleged to be an accidental death and one was alleged to be a natural death. Both the cases were found to be homicides upon autopsy. Police did not suspect homicide before autopsy in 4% of cases in a study done by Wahlsten et al.[11]

Revenge was the motive for killing in majority of cases (85.9%) which is reasonably a conscious and preplanned crime. Arguments which includes personal and social conflicts was the second most common reason (5.6%). This shows that most of the quarrels start over a trivial reason but gets terminated into the causation of crime due to aggression and provocation. Other motives for murder in our study were infidelity, property and financial conflicts. The present study correlates with that of Mohanty et al.,[12] and Basappa et al.[6] where revenge was the common motive but is in contrast to that of Parmar et al.[8] where an argument was the major motive. According to the author, the offenders are influenced by religious and political affairs coupled with aggression, which on circumstances instigates them to commit a crime. Psychological counseling and investigation to look beyond the motive for murder may prove to be beneficial in such instances.

A maximum number of individuals were victimized on the street/road (73.2%) followed by Hotel/Bar/Restaurant (14%) which were because of revenge and arguments. Studies done by Mohanty et al.[13] and Shivkumar et al.[14] also found outdoors to be the commonplace of occurrence similar to our study. Our results are in contrast to that of Basappa et al.[6] and Kominato et al.[10] where the majority of homicides took place indoors.

The maximum number of the homicides took place in the afternoon (33.8%) and evening (32.35%) which is similar to study conducted by Vougiousklakis et al.[15] but is dissimilar with a study by Basappa et al.[6] where the maximum number of cases occurred in the evening.

Majority of homicidal offenses were in Bangalore Urban region (63.3%) followed by Bangalore Rural (29.5%). The high number in the urban region of Bangalore may be attributed to rapidly growing urbanization, migratory population, relatively easy access to addictive substances, increasing competitiveness, jealousy and difficulties in establishing themselves (survival of fittest) when compared to rural areas of the city.

Use of only sharp weapons (38%) for homicide was more common than use of only blunt weapons (25%). This finding correlates with study done by Parmar et al.[8] and Basappa et al.[6] though it is in contrast with the studies of Ghambhir et al.[9] and Patel et al.[7] where hard and blunt weapons were the common weapons used for homicide. Sharp weapon usage in homicidal cases may be due to easy availability of such weapons in the city but its exclusive use also hints towards preplanned crime. Use of only blunt weapons for homicide could be attributed to an unpremeditated aggressive response. Similarly, sudden explosiveness can be assumed in 11.25% of victims who were murdered by asphyxia modes of death (Ligature, manual strangulation, smothering or drowning) in the present study. The incidence of firearm use was in just one case because the law in India is strict when compared to western countries where legislation governing gun licensing is relaxed.

## Conclusions

The present prospective analysis of homicidal death was an attempt to unravel various aspects and form a profile of homicidal deaths in the city. The observations though may have their own geographic, cultural, social, political and personal factors playing a role which changes over time, we feel that common aspect is intolerance and lack of patience. Limitation of the present study was that it was confined to a particular region and was limited to one-year period. Multicenter studies and studies for a longer duration are needed to have an accurate idea of trends of homicidal deaths in our country.

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ORIGINAL ARTICLE

# Retrospective analysis of death due to burns in a tertiary care hospital in North Tamil Nadu

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**Abstract**
Burns is a major cause of death in India and thousands die every year. Burn injuries are one of the major sources of morbidity and mortality and is an important public health problem. Over 96% of fatal burns occur in low and middle income countries. This retrospective study was carried out on autopsies of burn victims at the Department of Forensic Medicine & Toxicology, Government Villupuram Medical College, Villupuramfor a period of 5 years. It was done to study the profile of these cases. Out of the 4036 autopsies done, 89 cases were due to burns. 25 (28.09%) were males and 64 (71.91%) were females. 35 (39.33%) cases were in the age group of 21-30 years and 20 (22.47%) were in the age group 31-40 years. Most of the deaths were reported between 6 pm and midnight (32.58%). In 91.01% of the cases, burns occurred inside the house. Deaths occurred after the victims were hospitalized in 67.42% and 32.58% deaths occurred on the spot or were declared brought dead to hospital. The cause of death was due to burns shock in 83.15% and due to septicemia in 16.85%. Suicidal burns seem to be common among females of this region. The study clearly indicated decreased survival period related to an increased percentage of burns. Prevention programs should be directed at behavioral and social changes which can be easily adapted into thelifestyle of the public.

**Keywords**
Burns; Autopsy; Manner of death; Septicemia; Prevention programs

## Introduction

A burn is an injury to the skin or any tissue primarily caused by heat, radiation, electricity, friction and chemicals. Globally, burns are a serious public health problem. The World Health Organization estimates that each year over 3 lakh people die from flame or fire-related burns.[1] Living tissues are vulnerable to temperatures more than 50°C and the damage depends upon the intensity of temperature and the duration of exposure to the source of burn. Damage can occur even at 44°C on prolonged contact.[2] Over 95% of fatal fire-related burns occur in low and middle-income countries. South-East Asia alone accounts for over one-half of the total number of fire-related deaths worldwide. Females in this region have the highest fire-related mortality rates. In addition to mortality, millions are left with lifelong disabilities and disfigurements, resulting in stigma and rejection.[3]

## Materials and Methods

This observational, retrospective analytical study was done in the Department of Forensic Medicine, Government Villupuram Medical College, Villupuram, North Tamil Nadu for a period of 5 years from January 2012 to December 2016. Ethical committee clearance was obtained prior to taking up the study. Inclusion criteria included all autopsy cases of deaths from thermal, electrical and chemical burns. Deaths resulting from causes other than burns are excluded from this study. Data from the above autopsy case reports were collected and the following parameters were analysed: gender, age, religion, marital status, socioeconomic status, history of alcohol intake, season of the year, time zone of the day, place of occurrence, manner of death, dowry related or not. Further analysis was done to find out if death occurred before or after hospital admission, survival time since burns, presence of smell of kerosene, alcohol or poisons, extent and depth of burns, respiratory tract burns and cause of death.

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## Results

During this study period, out of 4036 medico-legal autopsies, the alleged cause of death was due to burns in 2.20% (n =89). Twenty five (28.09%) were males and 64 (71.91%) were females.Thirty five (39.33%) were in the 21-30 age group and 20 (22.47%) were in the 31-40 age group, in both the genders Table 1.

**Table 1:** Age distribution of the victims

| Age (years) | 2012 | 2013 | 2014 | 2015 | 2016 | Total (%) |
|---|---|---|---|---|---|---|
| 0-10 | 0 | 0 | 0 | 0 | 0 | 0 (0) |
| 11-20 | 1 | 2 | 2 | 3 | 1 | 09 (10.1) |
| 21-30 | 5 | 8 | 8 | 3 | 11 | 35 (39.33) |
| 31-40 | 4 | 1 | 6 | 4 | 5 | 20 (22.47) |
| 41-50 | 0 | 1 | 1 | 0 | 2 | 04 (4.49) |
| 51-60 | 1 | 1 | 2 | 4 | 2 | 10 (11.23) |
| >60 | 1 | 1 | 5 | 0 | 4 | 11 (12.36) |
| Total | 12 | 14 | 24 | 14 | 25 | 89 (100) |

Considering religion, the highest 93.26% (n=83) were Hindus and 3.37% (n=3) were Christians and Muslimseach. Among the victims, 73 (82.02%) were married while 16 (17.98%) were unmarried. Considering the socio economic status, 52 (58.43%) were house wives, 17 (19.10%)were labourers, 3 (3.37%) were employed and others were unemployed/students Table 2.

Seventy seven (86.52%) were living with their family and 12 (13.48%) were living alone. In majority of the victims i.e. 95.51% (n=85), there was no history of alcohol intake.

**Table 2:** Occupation of the victims

| Occupation | 2012 | 2013 | 2014 | 2015 | 2016 | Total (%) |
|---|---|---|---|---|---|---|
| Labourer | 4 | 3 | 4 | 2 | 4 | 17 (19.1) |
| Students | 1 | 1 | 2 | 0 | 1 | 05 (5.6) |
| House wife | 6 | 8 | 16 | 8 | 14 | 52 (58.4) |
| Unemployed | 1 | 2 | 2 | 2 | 5 | 12 (13.5) |
| Employed | 0 | 0 | 0 | 2 | 1 | 03 (3.4) |
| Total | 12 | 14 | 24 | 14 | 25 | 89 (100) |

On the whole, from January to March, there were 28.09% (n=25) deaths, April to June - 21.34% (n=19), July to September – 25.85% (n=23), and October to December – 24.72% (n=22). Maximum deaths, 32.58% (n=29) were reported between 6 pm and midnight, followed by 31.47% (n=28) from 6 am to noon, then 22.47% (n=20) from noon to 6pm and the least 13.48% (n=12) from mid-night to 6 am. In 91.01% (n=81), burns occurred in a closed space - inside the house and 8.99% (n=8) occurred in an open space - outside the house. In 67.42% (n=60) death occurred after hospitalisation and in 32.58% (n=29) death occurred either on the spot or were declared brought dead to the hospital.

Among the hospitalised victims, 55% (n= 33) died within 24 hours, 12% (n= 12) within 1 to 3 days and only one survived for 38 days Table 3.

**Table 3:** Survival period of the victims (n=60)

| Survival | N | % |
|---|---|---|
| 0-24 hours | 33 | 55 |
| 1-3 days | 12 | 20 |
| 4-7 days | 2 | 3.33 |
| 8-14 days | 5 | 8.33 |
| 15-30 days | 7 | 11.67 |
| > 1 month | 1 | 1.67 |

The manner of death was suicidal in 68.54% (n = 61), accidental in 24.72% (n=22) and homicidal in 6.74% (n=6) Table 4.

**Table 4:** Manner of death

| Manner | 2012 | 2013 | 2014 | 2015 | 2016 | Total (%) |
|---|---|---|---|---|---|---|
| Accidental | 5 | 4 | 6 | 1 | 6 | 22 (24.72) |
| Suicidal | 6 | 9 | 15 | 13 | 18 | 61 (68.54) |
| Homicidal | 1 | 1 | 3 | 0 | 1 | 06 (6.74) |
| Total | 12 | 14 | 24 | 14 | 25 | 89 (100) |

The history suggestive of dowry related death was noted in 9 cases. Eleven victims had history of psychiatric illness and treatment. All cases were flame burns. Kerosene smell was absent in 67.42% (n=60) and present in 32.58% (n=29).

In 50.56% (n=45), the whole of the body (100%) was burnt, in 25.84% (n= 23), 51% - 80% of the body surface area (BSA), followed by 81% - 99% of BSA in 17.98% (n=16) and less than 50% of BSA in 5.62% (n=5) Table 5.

The depth of the burns was III degree in 50 cases (56.18%), a mixture of II and III degree in the remaining 39 cases (43.82%) Table 6.

**Table 5:** Extent of burns

| Extent | 2012 | 2013 | 2014 | 2015 | 2016 | Total (%) |
|---|---|---|---|---|---|---|
| <50% BSA | 1 | 1 | 1 | 0 | 2 | 05 (5.62) |
| 51-80% BSA | 2 | 6 | 10 | 2 | 3 | 23 (25.84) |
| 81-99% BSA | 2 | 1 | 5 | 3 | 5 | 16 (17.98) |
| 100% BSA | 7 | 6 | 8 | 9 | 15 | 45 (50.56) |
| Total | 12 | 14 | 24 | 14 | 25 | 89 (100) |

**Table 6:** Depth of burns

| Depth | 2012 | 2013 | 2014 | 2015 | 2016 | Total (%) |
|---|---|---|---|---|---|---|
| 2nd& 3rd degree/ Mixed burn | 11 | 9 | 10 | 5 | 4 | 39 (43.82) |
| 3rd degree/ Deep burn | 1 | 5 | 14 | 9 | 21 | 50 (56.18) |
| Total | 12 | 14 | 24 | 14 | 25 | 89 (100) |

There was soot in the nostrils and respiratory tract in 39.33% of cases (n= 35) and absent in 60.67% (n=54). The cause of death was due to burns shock in 83.15% (n=74) and due to septicaemia in 16.85%(n=15).

There were 2 cases of associated head injury along with burns. None of the samples sent for chemical analysis showed presence of alcohol or poisons. There was 1 case of an unmarried pregnant girl with suicidal burns.

One case each, of suicidal burns, involving both - a husband and wife, a mother and daughter, a married lady and her paramour and two lovers - were seen.

## Discussion

In our study, there was a predominance of females (71.91%) and a majority of them (61.80%) were in the economically productive age group 21-40 years. Similarly, in an earlier study from Chandigarh (India), it was observed that most burn deaths occurred in the age group of 21-40 years (67%), with female preponderance (61%) in all age groups.[4] Memchoubi et al on the contrary reported a slight male preponderance of 50.76% over 49.23% of females.[5]

The age group most involved was 21-30 years with an incidence of 38.46%, which was more in females. In a study from New Delhi, by Chaudhary BL et al, it was noted that 88 (42.51%) of the cases were in the 21-30 years of age group in both gender.[1]Buchade D et al reports, female were most commonly affected than males.[6] The age group of 21-30 years with 97 cases (40.93%) was most commonly affected followed by 31-40 years with 54 cases (22.79%).

In our study, most of the victims were Hindus (93.26%) corresponding to the population in this region. In our study, majority of them i.e., 82%, are married. Buchade D et al also reported married females 114 (76.51%) were most common victims.[6] Most of our female victims were housewives (58.43%) and men were labourers, corresponding to the work pattern in

this part of the country. In our study, 86.52% were living with family, hence there was someone to share their problems and 13.48% were living alone.

Alcoholism does not appear to be a reason for suicide as only 4.49% of the victims gave history of alcohol intake. In a study by Godwin Y et al, greater burn involvement among males was observed in Cape Town, may be due to or exacerbated by the elevated levels of alcohol consumption.[7] There was not much of a difference as far as the season of the year were concerned in our study. In our study majority of the burns occurred between 6 pm and midnight and between 6 am and noon, when everyone is awake and at home. Chaudhary BL et al has said that maximum incidents occurred between 6 pm and midnight - 80 (38.64%) cases followed by 51 (34.63%) cases between noon and 6 pm.[1]

In our study 91 % (n=81) occurred inside the house in closed space corresponding to the most common form of suicidal burns. Chawla R et al reported that most of the burns were domestic, with cooking being the most prevalent activity.[8] In our study, the most common manner of the burn was suicidal (68.54%), followed by accidental (24.72%), whereas, Chaudhary BL et al reported, accidental (72.94%), followed by suicidal (17.39%) and homicidal (9.66%).[1] Memchoubi et al, also reported accidental, 35.38%, followed by homicidal, 29.23% and suicidal, 24.61%.[5]

All were due to flame burns. In a study from Chennai (India) on 555 burn cases in the age group of 0-18 years, scalds were the most common type of burns among children under 4 years of age, and flame burns predominated in the older age group.[9] Buchade D et al reported that thermal burns 184 (77.63%) was most common followed by electrical burns 23 (9.71%).[6]

In our study, 67.42% deaths occurred after the victims were hospitalised and 32.58% deaths occurred on the spot or declared brought dead. Among the hospitalised patients, 67% died within 3 days. Only one survived for 38 days. Memchoubi et al reported, 50.76% died in the hospital, 49.23% at the site of occurrence and 49.23% died within an hour of sustaining burns, 21.53% cases survived for more than 1 week.[5] Chaudhary BL et al reported that in 42 cases (20.28%) the period of survival was between 7 to 15 days followed by 3 to 7 days in 39 (18.84%) cases.[1] The maximum period of survival in a single case was 59 days.

Smell of kerosene was present in 32.58% of cases. Chaudhary BL et al reported that smell of kerosene was present in 38.88% of total female deaths. Chawla R et al, reported that smell of kerosene was present in 4% cases.[8]

In our study, in 50% of cases, the whole body (100% BSA) was burnt. In his study Memchoubi et al, observed that in about 73.84%, >80% body surface area was involved.[5] Chawla R et al, reported that the most of victims sustained 51 to 75% burns in 133cases i.e., (56.12%).[8] Chaudhary BL et al reported in 96 (46.37%) cases total body surface area of burn was between 90 to 100% followed by 80-90% in 29 (14.00%) cases.[1]

Majority of the cases had III degree burns - 56.18% and in the rest, it was a mixture of II and III degree. Chawla R et al, reported that maximum burns were of III degree.[8] In our study there was evidence of inhalational burns with soot in nostrils and respiratory tract in 39.33%.

The cause of death in majority of cases was burns shock (83.15%) and septicaemia in (16.85%). Memchoubi et al, reported burn shock as the cause of death in 67.69% cases.[5] In the study by Ramakrishnan KM et al, septicemia was the major cause of death (55%).[9] In a study on 352 patients, in Asian National Burn Centre, 16 deaths occurred and the final causes of death were septicaemic shock in 10 patients, extensive burns in 4, adverse drug reaction in one and bleeding peptic ulcer in one.[10]

## Conclusions

Burn injuries are one of the major causes of morbidity and mortality and have become an important public health problem. Suicidal burns seem to be common among females of North Tamil Nadu. Women outnumbered men and most of them are in the economically productive age group. Suicidal burns in the form of flame burns were the most common manner of burn injuries involved and are therefore preventable.

Our study clearly indicates a decreased survival of victims which is related to an increased percentage of burns and burn shock as the cause of death. Social factors like dowry are the main reason for the high rate of suicidal burn injuries in our society.

Prevention programmes can be adopted into lifestyles, and should be directed at behavioural changes, family support and counselling teens and married couples. Further research is needed to analyse the usefulness of any precautionary measure aimed at high risk groups, especially young females.

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ORIGINAL ARTICLE

# Knowledge, awareness and attitude towards organ donation among undergraduate medical students of Haryana

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**Abstract**

The knowledge and attitude of society toward organ donation is far from satisfactory even among the educated sections. Since medical students are the future doctors of the country, their optimistic attitude and elevated knowledge can build a constructive environment and encourage organ donation. A descriptive, cross-sectional study was carried out on undergraduate medical students of a Government Medical College of Southern Haryana. A questionnaire was adopted to know the knowledge, awareness and attitude of medical students toward organ donation. The data obtained from answer sheet was evaluated and incorporated on Microsoft Excel sheet, and descriptive analysis in terms of mean, standard deviation and percentage was carried out. A total of 249 medical students comprising of with 185 males and 64 females took part in the study. A steady increase in awareness of organ donation was seen from 81.08% to 86.07% from 1st MBBS to 3rd MBBS years of education. Television was found to be the most effective source of awareness (70.27%) of organ donation for 1st MBBS students while medical college was the maximum source (78.48%) of awareness for 3rd MBBS medical students. 70.88% 3rd year medical students expressed their willingness to be an organ donor, and the majority of them are willing to donate for their family members as compared to a friend or unknown person. More emphasis on the topic of organ donation in the medical curriculum should be given. This will help to fill the gaps and lack of knowledge regarding organ donation and issues related therewith.

**Keywords**

Organ donation; Transplantation; Medical; Students; Brain dead

## Introduction

Organ donation is the practice of surgically removing an organ or tissue from one person (donor) and placing it into another person (recipient) who is in need of that.[1] It is the gift of an individual to aid somebody who requires an organ for his morbid condition. Transplantation has significantly improved the outlook of patients suffering from end stage of organ failure. It has been one of the greatest landmarks in the history of modern science.[2] Priceless human lives can be saved if ethically suitable quality organs are retrieved from a donor and transplanted to the desirable person in a prescribed time frame.[3] The first kidney transplant was done in India in the 1970's, since then it has been a leading destination for organ transplantation.[4] Lack of any legislation in that era lead to the rampant sale of human organs. It was then; The Transplantation of Human Organs Act (THOA) was enacted in 1994 with the objectives to provide the regulation of removal, storage and transplantation of human organs for therapeutic purpose and for the prevention of commercial dealings in human organs and for matters connected therewith or incidental thereto. This act, for the first time recognized brain death for facilitating retrieval of organs. The act was further strengthened and amended with new rules and regulations in 2008, 2011 and 2014.[5-8] Organ donation is yet to gain impetus in India even after the decades of implementation of legislation. The knowledge and attitude of a society toward organ donation is far from satisfactory even among the educated sections.[9] Since medical students are the future doctors of the country, their optimistic attitude and elevated knowledge can build a constructive environment and encourage organ donation. Hence, this study was carried out to determine the current level of knowledge of medical students and their attitude toward organ donation and to identify the areas of want of the knowledge and to further suggest counteractive measures to amplify the knowledge in those areas.

## Materials and Methods

A descriptive, cross-sectional study was carried out on undergraduate medical students of a Government Medical College of Southern Haryana. First, second and third year MBBS students were included in this study. Only those students who gave informed consent were incorporated. The methodology was explained to them in detail. A questionnaire adapted to the study requirements from the published research[10] was designed to know the knowledge and attitude of medical students toward organ donation. The questionnaires were pretested on a sample of ten undergraduate students and finalized after being thoroughly tested for clarity of the questions as well as time period required for response. These questionnaires were not incorporated in the final evaluation. The questionnaire comprises of structured questions with

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regard to demographic data, the level of knowledge and awareness toward organ donation and attitude of the subjects in regard to organ donation. Questionnaires were administered to the participating medical students in paper format. Students were asked to indicate their responses as a tick mark in appropriate columns and were instructed to give their own answers and discussion with peers was not permitted. A time period of 15 minutes for completion of the questionnaire was given to each student. The data obtained from the answer sheets was evaluated and incorporated on Microsoft Excel sheet and descriptive analysis in terms of mean, standard deviation and percentage was carried out.

## Results

A total of 249 medical students comprising of 185 males and 64 females took part in the study (Table 1).

**Table 1:** Demographic data of the study participants

| | 1st MBBS | 2nd MBBS | 3rd MBBS |
|---|---|---|---|
| Total | 74 | 96 | 79 |
| Males | 50 | 76 | 59 |
| Females | 24 | 20 | 20 |
| Age Range (in years) | 18 - 22 | 18-23 | 20-23 |
| Mean Age (in years) ± SD | 19.47 ± 1 | 20.44 ± 1.09 | 21.32 ± 0.98 |

The awareness of the subjects regarding organ donation, possible donors and source of awareness along with knowledge of brain death was obtained (Table 2) .

**Table 2:** Knowledge and awareness of organ donation and different categories of donors with specific knowledge of brain death

| Item Studied | 1st MBBS (N=74) | 2nd MBBS (N=96) | 3rd MBBS (N=79) |
|---|---|---|---|
| Awareness of organ donation | 60 (81.08%) | 82 (85.41%) | 68 (86.07%) |
| Awareness of possible donors | | | |
| a) Living healthy person | 32 (43.24%) | 28 (29.16%) | 43 (54.43%) |
| b) Brain dead | 18 (24.32%) | 37 (38.54%) | 22 (27.84%) |
| c) Already dead | 13 (17.56%) | 14 (14.58%) | 20 (25.31%) |
| d) Don't know | 13 (17.56%) | 21 (21.87%) | 14 (17.72%) |
| e) No answer | 02 (2.7%) | 08 (8.33%) | 04 (5.06%) |
| Source of awareness | | | |
| a) Newspaper | 51 (68.91%) | 51 (53.12%) | 39 (49.36%) |
| b) Television | 52 (70.27%) | 46 (47.91%) | 37 (46.83%) |
| c) Internet | 50 (67.56%) | 58 (60.41%) | 48 (60.75%) |
| d) Social Media | 43 (58.1%) | 58 (60.41%) | 45 (56.96%) |
| e) Family Members | 34 (45.94%) | 26 (27.08%) | 22 (27.84%) |
| f) Medical College | 51 (68.91%) | 55 (57.29%) | 62 (78.48%) |
| Knowledge of brain death | | | |
| a) Irreversible loss of brain functioning | 54 (72.97%) 11 (14.86%) | 75 (78.12%) 08 (8.33%) | 69 (87.34%) 17 (21.51%) |
| b) Patient on ventilator | 07 (9.45%) | 06 (6.25%) | 06 (7.59%) |
| c) Patient can recover from it | 00 | 00 | 00 |
| d) Body feels warm | 02 (2.7%) | 09 (9.37%) | 04 (5.06%) |

A slight but steady increase in awareness of organ donation was seen from 81.08% to 86.07% from 1st MBBS to 3rd MBBS years of education. Television was found to be the most effective source of awareness (70.27%) of organ donation for 1st MBBS students while medical college was maximum source (78.48%) of awareness for 3rd MBBS medical students.

Table 3 represents the level of knowledge of students about the different organs that can be donated, the related contraindications to organ donation and the ability of one donor to donate to multiple recipients. Knowledge about the organs that can be donated is seen maximum for eyes (95.58%) in all the medical students. Only 58.22% of 3rd MBBS students had knowledge about the present laws related to organ donation and transplantation.

**Table 3:** Knowledge about different organs donated and contraindications to organ donation

| Knowledge about | 1st MBBS (N=74) | 2nd MBBS (N=96) | 3rd MBBS (N=79) |
|---|---|---|---|
| Organ that can be donated | | | |
| a) Eye | 71 (95.94%) | 91 (94.79%) | 76 (96.20%) |
| b) Lung | 07 (9.45%) | 22 (22.91%) | 29 (36.70%) |
| c) Liver | 52 (70.27%) | 67 (69.79%) | 75 (94.93%) |
| d) Intestine | 05 (6.75%) | 06 (6.25%) | 03 (3.79%) |
| e) Heart | 55 (74.32%) | 72 (75%) | 73 (92.4%) |
| f) Stomach | 03 (4.05%) | 06 (6.25%) | 06 (7.59%) |
| g) Kidneys | 70 (94.59%) | 89 (92.70%) | 76 (96.2%) |
| h) Spleen | 08 (10.81%) | 18 (18.75%) | 22 (27.84%) |
| I) Skin | 17 (22.97%) | 29 (30.20%) | 44 (55.69%) |
| j) Pancreas | 08 (10.81%) | 11 (11.45%) | 15 (18.98%) |
| k) Bone Marrow | 51 (68.91%) | 61 (63.54%) | 59 (74.68%) |
| l) Bones | 06 (8.1%) | 09 (9.37%) | 23 (29.11%) |
| Organ donation can't be done if the donor: | | | |
| a) Is HIV, Hepatitis B or C + | 60 (81.08%) | 69 (71.87%) | 67 (84.81%) |
| b) If donor has active cancer | 40 (54.05%) | 62 (64.58%) | 49 (62.02%) |
| That one donor can donate to multiple recipients? | | | |
| a) Yes | 35 (47.29%) | 58 (60.41%) | 65 (82.27%) |
| b) No | 19 (25.67%) | 14 (14.58%) | 05 (6.32%) |
| c) Can't Say | 20 (27.02%) | 24 (25%) | 09 (11.39%) |

A majority of students believes that there is a need for the laws to govern the process of organ donation (Table 4).

**Table 4:** Knowledge of legalities related to organ donation

| Item Studied | 1st MBBS (N=74) | 2nd MBBS (N=96) | 3rd MBBS (N=79) |
|---|---|---|---|
| Is there need for laws to govern the process of organ donation? | | | |
| a) Yes | 69 (93.24%) | 78 (81.25%) | 71 (89.87%) |
| b) No | 02 (2.70%) | 03 (3.12%) | 04 (5.06%) |
| c) Can't Say | 03 (4.05%) | 15 (15.62%) | 04 (5.06%) |
| Are there laws regarding organ donation activity presently? | | | |
| a) Yes | 53 (71.62%) | 52 (54.16%) | 46 (58.22%) |
| b) No | 06 (8.1%) | 06 (6.25%) | 07 (8.86%) |
| c) Can't Say | 15 (20.27%) | 38 (39.58%) | 26 (32.91%) |
| Whether the family of deceased person can pledge his organs even if the person had not signed a donor card during his lifetime? | | | |
| a) Yes | 24 (32.43%) | 37 (38.54%) | 33 (41.77%) |
| b) No | 15 (20.27%) | 18 (18.75%) | 16 (20.25%) |
| c) Can't Say | 35 (47.29%) | 41 (42.7%) | 30 (37.97%) |

70.88% 3rd year medical students expressed their willingness to be an organ donor and majority of them are willing to donate for their family members as compared to friend or unknown person. A majority still doesn't believe in the system behind organ donation and transplantation (Table 5).

**Table 5:** Attitude towards organ donation, willingness to donate organs and to promote organ donation and reasons for unwillingness to be an organ donor

| Item Studied | 1st MBBS (N=74) | 2nd MBBS (N=96) | 3rd MBBS (N=79) |
|---|---|---|---|
| Would you like to be part of Organ donation group and motivate others for organ donation? | | | |
| a) Yes | 53 (71.62%) | 74 (77.08%) | 59 (74.68%) |
| b) No | 05 (6.75%) | 08 (8.33%) | 04 (5.06%) |
| c) Can't Say | 16 (21.62%) | 14 (14.58%) | 16 (20.25%) |
| Do you feel that organ donation is an individual social commitment? | | | |
| a) Yes | 47 (63.51%) | 61 (63.54%) | 61 (77.21%) |
| b) No | 09 (12.16%) | 12 (12.5%) | 11 (13.92%) |
| c) Can't Say | 18 (24.32%) | 23 (23.95%) | 07 (8.86%) |
| Would you like to be an organ donor? | | | |
| a) Yes | 53 (71.62%) | 63 (65.62%) | 56 (70.88%) |
| b) No | 02 (2.7%) | 14 (14.58%) | 02 (2.53%) |
| c) Can't Say | 19 (25.67%) | 19 (19.79%) | 21 (26.58%) |
| Whom would you like to donate to? | | | |
| a) Family | 56 (75.67%) | 73 (76.04%) | 43 (54.43%) |
| b) Friend | 15 (20.27%) | 26 (27.08%) | 19 (24.05%) |
| c) Unknown | 16 (21.62%) | 30 (31.25%) | 38 (48.1%) |
| d) No answer | 10 (13.51%) | 12 (12.5%) | 10 (12.65%) |
| Reasons for not opting for organ donation | | | |
| a) Do not believe in organ donation | 06 (8.1%) | 06 (6.25%) | 04 (5.06%) |
| b) Due to disfigurement involved | 24 (32.43%) | 17 (17.7%) | 08 (10.12%) |
| c) Do not believe whether system fair/unfair | 22 (29.72%) | 34 (35.41%) | 29 (36.7%) |
| d) No approach to center for organ donation | 06 (8.1%) | 18 (18.75%) | 16 (20.25%) |
| e) No answer | 17 (22.97%) | 21 (21.87%) | 23 (29.11%) |

## Discussion

About 9.5 million deaths ensuing in India annually out of which nearly one-lakh deaths occur due to organ failure.[11] There is an extensive gap between the demand and availability of organs required for transplantation. Only 0.34 individuals per millions of population donated in India while 36 persons per millions of population donated organs in Spain, 35 donated in Croatia, 27.02 donated in the United States in 2014.[12] National Organ and Tissue Transplant Organization (NOTTO), India reported 26132 living transplants while 1300 cadaveric donation since 1995. In the last 8 years (2011-2018) total 3929 organ donations occurred in Haryana out of which 3873 was living while 46 were cadaveric donations.[13] Nuh (earlier Mewat) district of Haryana, which is adjoining to the national capital, also figuring at the bottom of the Niti Aayog's recent list of 101 most backward districts in the country[14] reported nil organ donation as per NOTTO stats.[13]

Total of 249 undergraduate medical students participated in this study. While those in the 1st year of MBBS had just started their medical education, those in the 2nd year of MBBS were undergraduate students with some knowledge of pharmacology, microbiology, pathology and forensic medicine. The 3rd year students were the final year medical students who had started attending clinics and hospital regularly as per the Medical Council of India curriculum.

Regarding knowledge and awareness of organ donation and different categories of donors with specific knowledge of brain death, the third year MBBS students were found to be slightly more aware of organ donation (86.07%) than 1st MBBS students (81.08%). Increased awareness of 3rd MBBS students can be attributed to their knowledge gained during the course of study in a medical college. However, cent percent knowledge was still not seen as observed by Bharambe et al.[10] Our study shows low awareness among the students that a brain dead person could be a possible donor (1st MBBS- 24.32%, 3rd MBBS- 27.84%) while 43.5% students were aware of brain death in study conducted by Shah et al.[15] Medical college found to be leading source of awareness of organ donation with steady increase seen from 1st MBBS (68.91%) to 3rd MBBS (78.48%). The teaching of organ donation and transplantation in IInd year MBBS curriculum can be the reason behind the same. Somewhat similar findings observed by Bharambe et al.[10] Newspaper, internet and social media arealso observed as a valuable source of awareness in majority of all prof MBBS students, which was also observed by Sam et al[1], Shah et al.[15] and Cetin et al.[16] Sindhu et al. concluded in their study television (37.9%) was the predominant source of knowledge of medical students followed by the internet (21.3%), newspaper (16.6%), and only 10.1% of the students reported that they got the information from their medical schools which are inconsistent with our findings.[17]

For knowledge about the different organs donated and contraindications to organ donation, almost 95% of the students were aware of eye and kidney as the organs that can be donated. Similar results were observed by Sam et al[1] and Shah et al.[15] Extensive advertisement in both print and digital media for eye donation and negative publicity of kidney scandals in media as well as in movies could be the reason for the same. Awareness about different organs such as liver, heart, and bone marrow was comparatively low but progressive increase in knowledge about other possible organs that can be donated was observed from 1st MBBS to 3rd MBBS. Bharambe et al. made similar observations in their study.[10]

In the current study, 84.81% 3rd year MBBS students agreed that organ donation couldn't be done if a donor is HIV, Hepatitis B or C positive while 62.02% stated that active cancer patient couldn't donate their organs. 96.5% of nursing students agreed that hepatitis and cancer are a contraindication for organ donation.[18] It is a common myth in general public that one cannot donate an organ if he has been suffering from (or have had) hepatitis B or C. Steady increase in knowledge that single donor can donate to multiple recipients seen from 1st MBBS (47.29%) to 3rd MBBS (82.27%) medical students which can be attributed to the knowledge gained in medical college.

Regarding the legalities related to organ donation, the majority of students of 1st MBBS (93.24%), 2nd MBBS (81.25%) and 3rd MBBS (89.87%) felt that there is a need for laws to govern the process of organ donation while 67.7% students felt the same in the study conducted by Sam et al.[1] Only 58.22% of 3rd MBBS students have the knowledge, that there are laws prevalent to organ donation presently, while 71.62% of 1st MBBS students are aware of the prevailing laws related to organ donation. However, The Transplantation of Human Organs Act (THOA) was enacted in 1994 in India. Adithyan et al[9] observed that 96.9% medical students were aware about legality of organ donation in India while 56.6% students were aware about the same in study conducted by Sam et al.[1] 36% students were aware regarding local and international legislation with regard to organ donation in study conducted by Kaur et al.[18] Only 41.77% of 3rd MBBS students have the knowledge that the family of deceased person can pledge his organs even if the person had not signed a donor card during his life time while majority of students of all professionals (1st MBBS-47.29%, 2nd MBBS-42.7% and 3rd MBBS- 37.97%) didn't have the knowledge about the same. Our results were somewhat similar to what was observed by Sam et al.[1] and Bharambe et al.[10] It often happens that the family members have to take the decision of organ donation on behalf of the deceased person. Awareness of this issue and the legalities involved is necessary for all health care professionals to promote organ donation following "brain-death" of patients.[10]

For the attitude towards organ donation, willingness to donate organs and to promote organ donation and reasons for unwillingness to be an organ donor, more than 70% of students in each group agreed to be a part of organ donation group and motivate others for organ donation while 20.25% 3rd MBBS students unable to decide for the same, which is consistent with the results of the study conducted by Sam et al.[1] and Bharambe et al.[10] 53.07% high school students were willing to donate organs in a study conducted by Cetin et al. in Turkey.[16] While only 27.55% of students willing to donate organs in a study conducted by Giri et al.[19] 77.21% of 3rd MBBS students felt that organ donation is an individual social commitment, which is higher than their 1st and 2nd year counterparts. Bharambe et al. observed that 80.4% to 84.7% of the respondents were willing to participate in any organ donation promotional activity.[10]

The majority of the students were willing to donate the organs to their family members while 48.1% of 3rd MBBS students agreed to donate organs to unknown. 40.99% students were shown their preference for organ donation to their family members in the study conducted by Adithyan et al.[9] In the present study, 36.7% 3rd MBBS students and 35.41% 2nd MBBS students do not believe in the system that's why they are not opting for organ donation. In a study conducted by Sam et al., 29.4% of students did not believe in the ability of the system to support the donated organ until they reach a suitable donor.[1] Bharambe et al. concluded that 21.7% of the final year medical students were opting against organ donation as they did not believe in the ability of the medical infrastructure to take care of the donated organs until they reach a suitable donor.[10]

It was observed in a pilot study that single classroom exposure had the potential to increase knowledge levels of organ and tissue donation among secondary school students.[20] In a study on high school students in Turkey, it was concluded that educational program significantly boosted the students' knowledge and awareness related to organ donation and transplantation.[21]

## Conclusions

The present study concludes that knowledge of organ donation and related issues are still inadequate in medical students especially regarding concepts of 'brain-death' and other aspects such as legal requirements related to organ donation. More emphasis to the topic of organ donation in the medical curriculum should be given. This will help to fill the gaps and lack of knowledge regarding organ donation and issues related therewith. Other educational tools such as advertisements, exhibitions and campaigns at the grass root level, especially in rural areas can improve the awareness and attitude about organ donation among the general population also. Since media, social as well as electronic, is well established and accepted by masses; an initiative of broadcasting through these agencies should be made about the need for organ donation and legislative laws involved.

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ORIGINAL ARTICLE

# Profile of poisoning cases among females: A 5-year retrospective study from poison detection centre of a tertiary care hospital

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**Abstract**

Poisoning is a serious problem throughout the world that could be suicidal, homicidal or accidental. In India more than 50,000 people are dying every year from the exposure of poisonous compounds. In a developing country like India there is expansion of industrial and agricultural fields on a large scale which gives rise to more production of insecticides and its accessibility thereby increasing its exposure and toxicity. The objective of this study is to analyze the profile of Poisoning cases in females tested in Poison Detection Centre of a tertiary care hospital over a period of 5 years. It is a retrospective record-based study of all poisoning samples of females sent for analyzing to Poison Detection Centre (PDC) of KLE hospital, Belagavi from January 2012 to December 2016. The data regarding pattern of poisoning, age, occupation and basic demographics were collected from hospital records.The study included total 380 female cases of which 334 were positive for various poisonous compounds and 46 were negative for standards tested. The commonest age group was 19-29 years. Organophosphorus was commonest compound and least was Amitraz. The maximum number of cases reported were among illiterate and were from rural background involved in agricultural activities. The maximum deaths were seen with Organophosphorus compound. It is the need of hour to conduct health and poison awareness programs to keep a check on increasing rate of poisoning cases.

**Keywords**

Poisoning; Poison Detection Centre; Females; Rural

## Introduction

Poisoning is a serious problem throughout the world that could be suicidal, homicidal or accidental. In India more than 50,000 people are dying every year from the exposure of poisonous compounds.[1] In a developing country like India there is expansion of industrial and agricultural fields on a large scale which gives rise to more production of insecticides and its accessibility thereby increasing its exposure and toxicity. It has been noted in few studies that female out numbers male in poisoning cases that could be accounted to the fact that females are often exposed to violence by husband and the stress and strain of day to day life in our society.[2] The World Health Organization (WHO) estimates that about 3 million cases of poisoning occur every year in the world and about 1,93,460 deaths occur due to unintentional poisoning.[3] Of these 90% of fatal poisoning occurs in developing countries particularly among agricultural workers. According to the data of National Crime Records Bureau, accidental poisoning with 39.1% mortalities contribute the second most common cause of all accidental deaths in India after road and rail accidents while suicidal poisoning with 27.9% mortalities contributes the second most common cause of all suicidal deaths after hanging.[4] Poverty, unemployment, early marriage, illiteracy and unresolved psychological problems are major stress factors responsible for high incidence of suicidal deaths in rural areas. By knowing the profile of poisoning cases in a region will help us to take the preventive measures before only and will also help in its early diagnosis and treatment. The current study was conducted to analyze the profile of poisoning cases in females.

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## Materials and Methods

It is a 5-year retrospective study of all poisoning samples of females analyzed at Poison Detection Centre (PDC) of KLE Hospital attached to Jawaharlal Nehru Medical College, Belagavi from January 2012 to December 2016. The study included data regarding pattern of poisoning, age, occupation and basic demographics were collected along with the name of poisonous substances and outcome. All observations were recorded in specially designed proforma for study. Data was collected and then analyzed to determine the results. Statistical analysis was done by using SPSS software version 25 and the results were calculated in percentages.

## Results

The study included total 380 female cases of which 334 were positive for various poisonous compounds and 46 were negative for standards tested. Table 1 depicts that among females,

maximum number of cases 159 (47.6%) were in age group 19-29 years followed by 2-18 years (18.3%) and least were in age group >70 years. Table 2 depicts that 203 cases (60.8%) were from rural background as compared to 131 cases (39.2%) which were from urban background.

**Table 1:** Distribution of cases according to age

| Age group | Female | Percentage |
|---|---|---|
| <1 | 06 | 1.8 |
| 2-18 | 61 | 18.3 |
| 19-29 | 159 | 47.6 |
| 30-39 | 42 | 12.6 |
| 40-49 | 34 | 10.2 |
| 50-59 | 17 | 5.0 |
| 60-69 | 09 | 2.7 |
| >70 | 06 | 1.8 |
| Total | 334 | 100 |

**Table 2:** Distribution of cases according to place of residence

| Place of Residence | Number of cases | Percentage |
|---|---|---|
| Rural | 203 | 60.8 |
| Urban | 131 | 39.2 |
| Total | 334 | 100 |

231 cases (69.2%) were married while 103 cases (30.8%) were unmarried as shown in (Table 3). Table 4 depicts that the most vulnerable group was the people involved in agricultural activities 139 cases (41.6%) followed by housewife 131 cases (39.2%) and students 52 cases (15.6%). According to this study, 243 cases (72.8%) were illiterate as compared to 91 cases (27.2%) which were literate.

**Table 3:** Distribution of cases according to marital status

| Place of Residence | Number of cases | Percentage |
|---|---|---|
| Married | 231 | 69.2 |
| Unmarried | 103 | 30.8 |
| Total | 334 | 100 |

**Table 4:** Distribution of cases according to occupation

| Occupation | Number of cases | Percentage |
|---|---|---|
| Farmer | 139 | 41.6 |
| Housewife | 131 | 39.2 |
| Student | 52 | 15.6 |
| Self | 06 | 1.8 |
| Others | 06 | 1.8 |
| Total | 334 | 100 |

Table 5 depicts that organophosphorus 219 cases (65.6%) was the commonest poisonous compound used followed by medicine and drugs 53 cases (15.9%) and alcohol and phenol 16 cases (4.8%). The total mortality was 31 in which maximum mortality was seen with organophosphorus compounds. Table 6 depicts that when the patient arrived to hospital in less than 2 hours the mortality was 3 (9.7%) out of 92 cases. But as more time elapsed since exposure to hospital arrival more was the mortality.

**Table 5:** Distribution of cases according to type of poisoning and mortality

| Type of Poisoning | Number of patients | Percentage | Mortality | Percentage |
|---|---|---|---|---|
| Organophosphorus | 219 | 65.6 | 18 | 58.1 |
| Medicine and Drugs | 53 | 15.9 | 07 | 22.3 |
| Alcohol and Phenol | 16 | 4.8 | 02 | 6.4 |
| Carbamate | 10 | 2.9 | 01 | 3.3 |
| Bromodiolone | 14 | 4.2 | 01 | 3.3 |
| Pyrethroid | 06 | 1.8 | 01 | 3.3 |
| Amitraz | 02 | 0.6 | 00 | 00 |
| Others | 14 | 4.2 | 00 | 3.3 |
| Total | 334 | 100 | 31 | 100 |

**Table 6:** Distribution of cases according to time elapsed since exposure to hospital arrival; and their prognosis.

| Time lapsed to reach Hospital | Total cases | Expired cases |
|---|---|---|
| <2 hours | 92 (27.5%) | 03 (9.7%) |
| 2-4 hours | 110 (32.9%) | 04 (12.9%) |
| 5-8 hours | 89 (26.7%) | 11 (35.5%) |
| >8 hours | 43 (12.9%) | 13 (41.9%) |
| Total | 334 | 31 |

## Discussion

The present study shows that most of the cases belongs to age group 19-29 years which constitute 47.6% because this is the most active age group involved in agricultural and outdoor activities. This observation is consistent with the studies conducted by Tandleet al.,[5] Dash et al.,[6] and Srivastava et al.[7] In this study rural population (60.8%) is affected more as compared to urban population (39.2%) because rural people are more exposed to pesticides which is similar to findings noted by Tejaset al.[8] and Singh et al.[9]

A study done by Tandleet al.[5] revealed that married female subjects (69.2%) outnumbered unmarried subjects (30.8%) which is similar to our study. This is because married population is more exposed to strain and stress of life like co-handling agricultural field work alongwith husband, financial, social, and psychological problems and domestic violence. In this study it has been observed that the most vulnerable occupation group was the people involved in agricultural activities (41.6%) and people who were illiterate (72.8%) which is similar to studies done by Sandhu et al.,[10] Pate et al.[11] and Karamjit et al.[12]

According to a study done by Patilet al.[13] and Marahattaet al.[14] the organophosphorus poisoning (65.6%) constitute maximum number of cases followed by unspecified drugs (15.9%) which is similar to our findings.In our study, more the time elapsed since exposure to hospital arrival higher was the mortality which is similar to studies done by Gupta et al.[15] and Ramesha et al.[16]

## Conclusion

Most of the victims in our study were young illiterate, married, and from rural/agricultural background who consumed organophosphorus compounds predominantly. More centers of poison information should be established so that the people can

be educated about the dangers and toxicity of the poisons. Since pesticides are easily available in our country so in order to check their accessibility, stringent rules and regulations should be implemented. As it is clear in our study that most affected population is of youngsters so it is the need of hour to give them proper psychological counseling which will decrease the risk in future as well as morbidity and mortality. Various health programs should be organized to create awareness about the lethal effects of pesticides and common household articles.

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ORIGINAL ARTICLE

# Sexual dimorphism in unfused hyoid bones using weight as a parameter

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**Abstract**
The present study aims to determine the sexual dimorphism of unfused hyoid bone by using weight as a parameter. 286 unfused hyoid bones of known sex obtained from the cadavers brought to the mortuary for autopsy were included in the study. 4 measurements were made: weight of the right cornua, weight of the left cornua, weight of the body of the hyoid, and weight of the entire hyoid bone. Measurements were done using an electronic weighing scale and the observations were tabulated. All the measurements in male hyoid bones were greater than the measurementsin female hyoid bones. Univariate discriminant analysis was conducted on the data to estimate sex from the weight of the unfused hyoid bone. The accuracy ranged from 67.5% to 76.6% [62.1% - 73.4% in males and 75.2% - 81.2% in females]. Weights of different parts of unfused hyoid bone showed statistically significant results and can be used to estimate sex along with other parameters.

**Keywords**
Unfused hyoid bone; Weight; Sex determination; Sexual dimorphism; discriminant function analysis.

## Introduction

One of the crucial steps for forensic anthropologists in studying a set of human skeletal remains is to accurately estimate the sex of the individual. Accurate estimation of sex is important as most of the other skeletal remain analyses such as estimation of age and stature rely on the correct estimation of sex. Correct sex estimation is not only important to forensic specialist in successfully establishing the identity of unknown individuals, but also in generating demographic information of different populations. Therefore, forensic anthropologists must have reliable and accurate methods to estimate the sex of unidentified individuals. While the pelvis and the skull are the best indicators of the sex of a person, their unavailability may cause forensic anthropologists to rely upon other small bones or their fragments to estimate sex.

Hyoid bone is a U-shaped bone and part of viscerocranium placed between the tongue root and thyroid cartilage to which it is connected by thyrohyoid membrane. It is placed at the level of the fourth cervical vertebra and articulates with surrounding structures via muscles (suprahyoid and infrahyoid muscle groups) and ligaments (stylohyoid ligaments). It presents a median unpaired body, a long large cornu on each side, and a small nodule, the small cornu, situated above the junction of body and great cornu.[1] At the base of the hyoid bone, each small cornuis connected to the body by fibrous tissue and occasionally to the greater cornu by a synovial joint which might be ankylosed.[2] Until now, most researchers studied fused or articulated hyoid bone to assess its reliability in sexual differentiation along with other commonly used bones like long bones, skull and pelvis. But very few studies were conducted around the world to study the sexual dimorphism using unfused hyoid bone. The purpose of this research is to assess the presence of sexual dimorphism in the unfused hyoid bones and to consider whether weight as a parameter could be useful for sex estimation.

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## Materials and Methods

The present study was a cross-sectional study, conducted by purposive sampling of 286 unfused hyoid bones recovered from medico-legal autopsies over a period of two years after taking obtaining approval from the Institutional ethical committee. Unfused hyoid bone is defined as the hyoid bone where both the greater cornua (left and right) are unossified or disarticulated with the body of the hyoid. Out of the 286 unfused hyoid bones studied, 169 specimens were obtained from male cadavers and 117 from female cadavers. The age of the deceased ranged from 14 to 80 years. Unfused hyoid bones of all those cases in which the sex of the person to whom the hyoid belonged was known were included in this study. All hyoid bones measured in this study were from Northwestern Indian population. Unfused hyoid bones from individuals with any congenital anomalies, partially destroyed, fractured, burnt, diseased, deformed or abnormal hyoid bones were excluded from the study.

The hyoid bones were removed from the cadavers by careful dissection of the laryngeal structures during post-mortem examination and duly numbered after degreasing them with acetone. The bones were weighed on an electronic weighing balance.

Hyoid bone was dissected out by mid line incision extending from the chin to the sternal notch. After incision, the neck structures were dissected from the lower border of mandible and then tongue was separated and dissected along with neck structures. The unfused parts of hyoid bone thus collected were put in a numbered jar filled 3 quarters with tap water for maceration. Maceration was done without using any chemicals to avoid eroding the bone. The bone was examined regularly,

and when soft tissues were completely separated, the bone was cleaned by brushing the remaining soft tissues with a brush. After cleaning, the bone was dried at room temperature. Degreasing was done by placing the bone in acetone for few days. Digital weighing machine having air tight chamber was used to weigh the unfused hyoid bone. Weight of each part was measured in grams Three readings were recorded using the electronic weighing machine at different times and the average was recorded. The following four measurements were studied on unfused hyoid bones which include weight of lesser cornua also:

1. The weight of right cornua of unfused hyoid bone (WRC)
2. The weight of left cornua of unfused hyoid bone (WLC)
3. The weight of body of unfused hyoid bone (WB)
4. The weight of whole unfused hyoid (WCH)

All statistical tests were run using Statistical Package for the Social Sciences (SPSS version 20, SPSS Inc., Chicago, IL, USA) for Windows. First, paired samples t-tests were used to test for differences in weight between the right and left cornua of the same hyoid. Secondly, ANOVA was used to determine whether differences in weight between males and females were significant and *P*-values below 0.05 were taken to indicate a statistically significant difference in weight between males and females, supporting the hypothesis that sexual dimorphism is present in the sample. Thirdly, Univariate Discriminant function analysis was carried out to examine the dimorphism in the unfused hyoid and how the variables could be used to correctly estimate the proper sex. For each function, the percent accuracy for determining males was calculated by adding the total number of true determinations of sex, then dividing by the total number of males in the sample, and then multiplying by 100. This method was then repeated for the female hyoids.

## Results

Out of 286 unfused hyoid bone samples used, 169 (59.09%) were from male human corpse and 117 (40.91%) were from female. The results of this study produced coefficients from a sample of unossified hyoid bones recovered from Northwest Indian males and females in medicolegal autopsy cases.

**Table 1:** Paired t-test to compare weight ofleft and right greater cornua of unfused hyoid bone

| Variable Pair | Mean | SD | SEM | T Value | df | p-value |
|---|---|---|---|---|---|---|
| WRC<br>WLC | 0.1995<br>0.1992 | 0.077<br>0.073 | 0.005<br>0.004 | .145 | 285 | 0.885 |

WRC = Weight of right cornu; WLC = Weight of left cornu

Table 1 shows the results of the paired t-test conducted to compare the left and right greater cornua weights. There were no statistically significant differences between the weight of two cornua.

Table 2 shows the ANOVA analysis of all the parameters. All the measurements were highly significant, reflecting the sexual differences between male and female unfused hyoid bone when weight is used as a parameter.

Table 2 showed the value of Wilk's lambda and F-ratio of all the four variables. In this table, Wilk's lambda calculates how useful a given variable is, as well as the order of variables to enter the function. The F-ratio determines how much variation exists within and between the sexes and the significance level of the variance. ANOVA was calculated in order to compare the relative significance of sexual difference between the variables. The distinction ability of the discriminant function analysis was evaluated by looking at the canonical correlation and eigen values so that higher the canonical correlation and the closer the eigenvalue is to one, the higher the discrimination ability of the function.[3] The results from the univariate analysis that were greater than the sectioning point were considered male individuals, and results that were less than the sectioning point were considered female individuals, while the results that were equal to the sectioning point were classified as indeterminate. Fisher's coefficients are used to calculate discriminant scores for different variables.

**Table 2:** ANOVA and univariate discriminant function analysis on WRC, WLC, WB and WCH (in grams)

| Statistics | Sex | WRC | WLC | WB | WCH |
|---|---|---|---|---|---|
| Mean | Male | 0.226 | 0.224 | 0.554 | 0.998 |
| | Female | 0.161 | 0.163 | 0.367 | 0.691 |
| SD | Male | 0.074 | 0.071 | 0.161 | 0.287 |
| | Female | 0.064 | 0.058 | 0.139 | 0.240 |
| SEM | Male | 0.006 | 0.006 | 0.013 | 0.022 |
| | Female | 0.006 | 0.005 | 0.012 | 0.022 |
| P-value | | <0.001 | <0.001 | <0.001 | <0.001 |
| Mean ± 3SD | Male | 0.215-0.238 | 0.213-0.215 | 0.530-0.578 | 0.954-1.042 |
| | Female | 0.149-0.173 | 0.153-0.174 | 0.341-0.392 | 0.647-0.735 |
| Wilk's lambda | | 0.828 | 0.830 | 0.733 | 0.759 |
| F-ratio | | 59.081 | 58.346 | 103.600 | 90.164 |
| eigenvalue | | 0.208 | 0.205 | 0.365 | 0.317 |
| Canonical Correlation | | 0.415 | 0.413 | 0.517 | 0.491 |
| Sectioning point | | -0.357 | -0.355 | -0.473 | -0.442 |
| Fisher's Classification Coefficients | Male | 45.688 | 51.230 | 23.796 | 13.832 |
| | Female | 32.549 | 37.341 | 15.769 | 9.580 |
| Fisher's Classification Constants | Male | -5.254 | -6.434 | -7.278 | -7.595 |
| | Female | -3.315 | -3.743 | -3.585 | -4.004 |
| Canonical Discriminant Function Coefficients Unstandardised | Coefficients | 14.213 | 15.120 | 6.557 | 3.723 |
| | Constant | -2.836 | -3.013 | -3.128 | -3.248 |
| Percent Correctly classified by Discriminant function analysis | Male (%) | 65.7 | 62.1 | 73.4 | 72.8 |
| | Female (%) | 76.1 | 75.2 | 81.2 | 80.3 |
| | Overall (%) | 69.9 | 67.5 | 76.6 | 75.9 |

WRC = Weight of right cornu; WLC = Weight of left cornu; WB = Weight of body; WHC = Weight of whole unfused hyoid bone

The male identification point is the maximal weight in female bones and for the female bone identification point is the minimum weight in male bones. The area present between these points was called overlapping zone. Demarking points are obtained by calculating the maximum and minimum limits i.e. the range of a particular dimension. Addition of 3 standard deviations to the mean gives the maximum value and

subtraction of 3 standard deviations from the mean gives the minimum value. Demarking points were calculated above which no female bone could be found and this was the upper obtained range of female bone. Any bone having weight more than this was bound to be male. From the considered range of male bones, a demarking point was calculated below which no male bone could be found. Thus, any bone having weight less than this was bound to be female. Although identification and demarking points can identify sex accurately, but only a small proportion of hyoids can be sexed based on these methods as most of the remaining hyoids show the weight in the overlapping zone. Thus, the average of male and female identification points was calculated to be called as a limiting point. Limiting point so calculated was such that the vast number of male hyoid showed value greater than it and the bulk of female hyoid showed values lesser than this limiting point.

## Discussion

The hyoid bone has been established to be sexually dimorphic,[4] and research has looked into its use as a factor in the estimation of sex. Most research has focused on size and shape differences between sexes, and many have used a variety of statistical methods to attempt to produce standards that can be used to estimate sex in unknown human remains.[3,5-8]

In a study on the northwest Indian population, both sexes showed a considerable increase in measurements up to the age of 13 years and thus, sexual differences were insignificant up to this age because of which the lower limit for age in this study was set for 14 years.[9] However, there were earlier studies which reported age related changes in the weight of the hyoid bone where mean weight increased till age of 30-50 years and which decreased afterwards, but there was no significant sex differentiation correlations.[10-11] The weight of right and left side of hyoid bone of each individual were compared with t-test (Table 1).

Paired sample t-test found that there was no significant difference. This suggests that although the data used to develop the functions presented here was recorded according to the side, it is not necessary to discriminate between the right and left sides when using the functions. This will allow the user to utilize the functions when a partial hyoid is recovered or when it is difficult to distinguish one side from another.[12] In 1988, Ranjithand Pillai S[13] and in 1996, Harjeet and Jit[9] worked on the weight and morphometrics of hyoid bone respectively. Other Indian researchers also significantly concur the findings of these two researchers.[11,14-15] According to all these researchers; the mean weight of the hyoid bone in males was significantly greater than females. But all these previous studies which were conducted to assess the sexual dimorphism of hyoid bone were done on fused hyoid bone and also the use of discriminant function analysis for sex differentiation was somewhat limited.[9-11,13-15] As per our knowledge, no study till date has been published to assess the sexual dimorphic feature of unfused hyoid bone using weight as a parameter. Kindschuh et al.[12] D'Anastasio et al.[16] and Logar[17]studied unfused hyoid bones butdidnot use weight as a parameter. In the present study, unfused hyoid bones were used and the result showed that the mean weight of all the variables after degreasing in male hyoids was statistically significant (p value < 0.001) when compared with females. The present study examined the accuracy rates by univariate discriminant analysis created from the study population when applied for determination of sex from the weight of unfused hyoid bone with overall classification rates ranged from 67.5% to 76.6% [62.1% to 73.4% in males and 75.2% to 81.2% in females].

Table 3 showed another way of sexual differentiation which was brought out by identification, demarking and limiting points methods, evolved on the lines of Jit & Singh.[18] All these three ways are of less significance for practical purposes as they all showed very low percentage or accuracy regarding correct classification of the sex in hyoid bone because of overlapping measurements in the two sexes. All these measurements may be useful for classifying accuracy of long bones but not for hyoid bone particularly.

**Table 3:** Percentage of unfused hyoids classified using identification points (I.P.), demarking points (D.P.) and limiting points (L.P.)

| Variables | | WRC | WLC | WB | WCH |
|---|---|---|---|---|---|
| Identification points (I.P.) | Male | 0.451 | 0.42 | 0.857 | 1.63 |
| | Female | 0.028 | 0.026 | 0.059 | 0.113 |
| % Identified with I.P. | Male | 1 | 1 | 2 | 3 |
| | Female | 2 | 3 | 1 | 2 |
| Demarking points (D.P.) | Male | 0.356 | 0.346 | 0.797 | 1.444 |
| | Female | -0.013 | -0.006 | 0.027 | 0.087 |
| % Identified with D.P. | Male | 11 | 11 | 4 | 8 |
| | Female | - | - | 1 | 1 |
| Limiting point (L.P.) | | 0.254 | 0.236 | 0.488 | 0.928 |
| % Identified with L.P. | Male | 28 | 25 | 50 | 55 |
| | Female | 93 | 91 | 85 | 85 |

WRC = Weight of right cornu; WLC = Weight of left cornu; WB = Weight of body; WHC = Weight of whole unfused hyoid bone

## Conclusions

The readings of the male unfused hyoid bone for the most of the parameters were greater when compared to the values of female bones. In most of the parameters, there was a clear demarcation between the value of male and female bone. For estimating sex in these bones, single parameter may not be sufficient to decide the sex of the bones and it becomes crucial to include other parameters also before deciding the sex of an unknown unfused hyoid bone.

The study however, has its limitations. Age related changes in weight of hyoid bone were not taken into consideration. Other factors influencing weight of the bone like height, weight, nutrition, or health status of the individual were not taken into deliberation in this study. For accurate sex estimation, other morphometric and morphological measurements should also be studied. Use of identification point, demarking and limiting point has less practical utility in estimating sexual dimorphism of hyoid bone.

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ORIGINAL ARTICLE

# Coronary Artery Disease (CAD) in young Indians: An autopsy study

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**Abstract**

Coronary Artery Disease (CAD) is a leading cause of death worldwide. Atherosclerosis, the cause of CAD, is emerging as the single largest disease accounting for nearly one-third of all deaths in India. A study to evaluate the Microscopic Grading of CAD in young individuals and to find its relationship with the age and sex was done for one year. Tissues of coronary artery from 55 cases of medico legal autopsy were collected and studied for Histopathology. The findings were graded as per guidelines of American Heart Association. Out of 18 patients in the age group less than 30 years, 16 (77.8%) were males and 2 (22.2%) were females. Out of 37 cases (30 –39 years), 26 were males (70.3%) and 11 females (29.7%). Out of 37cases belonging to the age group of 30-39 years, 7(18.9%) cases had type I-III changes while30(81.1%) cases had type IV-VI changes [$\chi^2$ (5) = 30.65 p = 0.000 (confidence interval 95%)]. According to our study, young Indians dying due to non-cardiac causes show significant positive CAD changes. This is quite high in comparison with corresponding non-Indian cohorts. Majority affected were males (40/55:72.7%) as compared to the females. The high Incidence of CAD in young people is quite alarming. The data obtained may form a baseline for the forthcoming studies of CAD, especially if done on a multi-centric basis.

**Keywords**

Atherosclerosis; Autopsy; Young; Histopathology; India

## Introduction

Atherosclerosis is a disease of the arterial wall that occurs at susceptible sites in the major conduit arteries. It is initiated by lipid retention, oxidation, and modification, which provoke chronic inflammation, ultimately causing thrombosis or stenosis. Several risk factors may intensify or provoke atherosclerosis including hypertension, tobacco smoking, diabetes mellitus, obesity, etc.

The processes and histological changes can vary considerably among ethnic groups and within any given individual. In the natural course of atherosclerosis, spontaneous regression of early stage lesions may occur, but the intermediate and advanced stages appear to be progressive.[1] CAD is a disease of old persons but presently young are also affected considerably. There is lack of sufficient morphological data regarding CAD/ atherosclerosis in our country. The present autopsy based study is thus, intended to focus on finding the prevalence of CAD in young individuals.

## Materials and Methods

The present prospective observational study was taken up during 1st July 2017 to 30th June 2018, after obtaining the approval from the Institutional Ethical Committee.

*Inclusion Criteria:* Deceased persons between 20-39 years, who were brought to hospital morgue for medico legal autopsy within the time period mentioned, who died due to non-cardiac cause, had no ante mortem history of cardiac illness, hypertension, diabetes mellitus etc., no family history of cardiac illness in the family, were selected.

*Exclusion Criteria:* Deceased of any age greater than 39 years and below 20 years, history of any known cardiac illness, family history of hypertension and diabetes; death due to any cardiac cause detected after autopsy; decomposed body; any injury on the chest if present where heart was partly or completely damaged.

Among all the cases brought to hospital morgue for autopsy within study period, 55 autopsy cases fulfilled all inclusion and exclusion criteria; so, study population was 55. The age of the subjects was categorised into two age groups: Group 1: 20-29 years (3rd decade), and Group 2: 30-39 years (4th decade). 3rd decade of life forms the watershed age group for the development of Coronary Atherosclerosis; it is in this age group where the propensity of development of significant atheroma in coronary arteries increases in proportion exponentially. The following procedures were followed and analysed statistically.

*1) Gross or macroscopic changes:*

- Selection of coronary artery: To delineate the changes in the Coronary artery, macroscopically, dissection along the cross-section of the Left Anterior Descending Artery was done, near its root (at the point of bifurcation of the Left Coronary Artery into Left Anterior Descending Artery (LADA) and Left Circumflex Artery (LCA) up to1 cm distance. This is an important site for atherosclerosis, only second to abdominal aorta.[2]

- Grossing of selected area: While employing the transverse sectioning technique, a sharp scalpel blade was used to slice completely through the arteries at intervals of not more than 0.3 cm proximal where atheroma and thrombus was more likely.

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The longitudinal opening technique was not used in our study.

Evidence of any macroscopic thrombus or any luminal stenosis were looked for in the coronary arteries being examined.[3]

*2) Histopathology Examinations:* This was performed following standard procedure and the results were noted. Standard Haematoxylin and Eosin stain and Reticulin stain were used.

Stained slides were studied under the microscope to identify any pathological changes in the coronary artery tissue. The findings were graded according to the histopathology grades of atherosclerosis as given by the American Heart Association which is mentioned below.

Type I**:** Isolated intimal foamy cell (minimal change)

Type II**:** Numerous intimal foamy cells often in layers (fatty streaks)

Type III**:** Pools of extracellular lipids without a well-defined core (intermediate lesion or pre-atheroma)

Type IV**:** Well defined lipid core with luminal surface covered by normal intima (atheroma or fibroplaque)

Type V: Lipid core with a fibrous cap with or without calcification (fibroatheroma)

Type VI: Fibroatheroma with cap defect such as haemorrhage or thrombosis

Type VII: Calcification prominent

Type VIII: Fibrous tissue change prominent [2]

*Statistical analysis:* The association of the Histopathology grades with the age of the subjects were analysed using standard statistical tools [SPSS (IBM Statistical Package for Social Sciences Software version 25.0)].

## Results

The study participants comprised of 40 males and 15 females. Thus, male individuals are more affected by coronary atherosclerosis as compared to females. In the present study, 18 cases belonged to the 3rd decade whereas the other 37 were in their 4th decade. The age and sex distribution of the study groups is shown in Table 1.

**Table 1:** Age and sex distribution of the study cases (n =55)

| Age Group (years) | Male | Female | Total |
|---|---|---|---|
| Group 1 (20-29 years) | 14 (77.8%) | 04 (22.2%) | 18 (100.0%) |
| Group II (30-39 years) | 26 (70.3%) | 11 (29.7%) | 37 (100.0%) |
| Total | 40 (72.7%) | 15 (27.3%) | 55 (100.0%) |

Cross- tabulation of age groups with the histopathological grades of CAD is shown in Table 2.

**Table 2:** Histopathological grading of coronary atherosclerosis in the study groups (As per the American Heart Association classification)

| Histopathological Grade (AHA) | Type I–III | Type IV-VI | Total |
|---|---|---|---|
| Group 1 (20-29 years) | 16 (88.9%) | 02 (11.1%) | 18 (100.0%) |
| Group II (30-39 years) | 07 (18.9%) | 30 (81.1%) | 37(100.0%) |
| Total | 23 (41.8%) | 32 (58.2%) | 55 (100.0%) |

Age was found to be significantly associated with increase in histopathology grade; $\chi^2$ (5) = 30.65; p<0.001 (Confidence Interval = 95%)]. Age and histopathological grade were significantly and positively correlated (r = 0.617 p <0.001), as is apparent in Fig. 1.

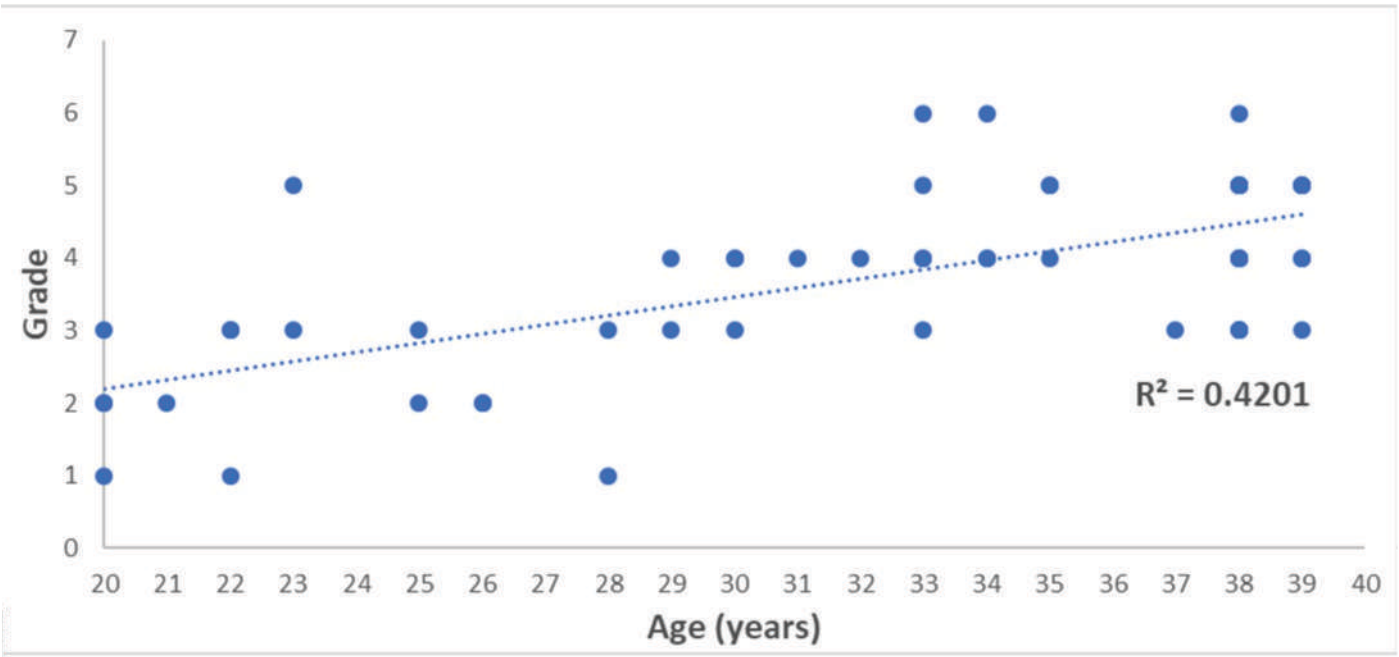


**Fig. 1:** Correlation between age and the histopathological grading of coronary atherosclerosis as per American Heart Association classification

## Discussion

Coronary artery disease is a rising problem globally. In the last quarter it has risen to explosive proportions, even more in the developing countries (3rd world countries) of the world. With the shift of the global health focus from the infectious disease to the non-infectious ones as the major *'killers'* in the society, CAD, leading to subsequent Ischemic Heart Disease (IHD) takes the pivotal position among all the other problems that we face in the current circumstances.[4]

The study Garg et al. [5]comprises of the cases in age group of 15 to 85 years. 46.4% showed significant atheroma. Left anterior descending artery was most commonly involved artery amongst all coronary arteries and second to abdominal aorta. Atheroma have been seen above the age of 15 years, but significant atheroma appeared after third decade onward, as is seen in our current study, atheromatous change is seen from 20 years of age and significant atheromatous changes (Type IV and beyond) seen after 30 years of age (4$^{th}$decade).

Sharma et al. [6] pointed out that atheroma was seen above the age of 20 years but significant atheroma appeared after third decade, which finding is consistent with our study. Vyas et al.[7] pointed out that 3$^{rd}$ decade of life appears to be a watershed line in the pathogenesis of coronary vascular atherosclerosis. We also observed in our present study, a steady increase in overall frequency and severity of atherosclerosis from the 3rd decade onwards.

Deorajpuri et al. [8] reported that, with advancing age, there is fraying, splitting, fragmentation of the Internal Elastic Lamina (IEL), leading to splitting of the IEL into two layers in between 31-40 years of age, thus enclosing the adjacent smooth muscle layer (so-called 'musculo-elastic layer'). This finding is consistent with our study, as atheromatous changes are more pronounced beyond 30 years of age. Hathila et al. [9] showed most common age group for atherosclerotic changes was in 31-40 years.

In Kumar et al.[10] study, autopsy of 50 cases were done within 12 hours of death due to some unnatural cause. In the age group between 30-40 years, out of 21 males and 2 females of age group 30-40 years, 18 (85.71%) males and 1(50%) female were affected. In our study, however, 100% cases are affected, showing higher propensity of development of atherosclerosis with respect to age. Dhall et al.[11]study showed that incidence of coronary artery disease is much higher in men than in women until the fifth decades of life, which again is consistent with our findings as we only considered the age group of 20-39 years (3$^{rd}$ and 4$^{th}$ decade).

Keche et al.[12] showed that the study subjects were 90 (75%) males and 30 (25%) females. Prabhu et al.[13] found that among the 50 (70%) cases studied, 35 (30%) were males and 15 were females. Jain et al.[14]in their study found, out of 150 cases studied, 28 cases including 16 males and 12 females showed normal histology in all three major coronaries. Coronary atherosclerosis was present in 122 cases (81.3%) with mean age of 43 years. 85.9% (98/114) males and 66.6% (24/36) females had coronary atherosclerosis. Thus, this study had findings consistent with our findings as males were more affected than females.

McGill et al.[15]in their study for pathobiological Determinants of atherosclerosis in Youth (PDAY) Research Group showed approximately 19% of 30 to 34 years old men and 8% of 30 to 34 years old women had atherosclerotic stenosis in 40% in the left anterior descending artery (LAD), again being consistent with the findings of Our study. Berenson et al.[16] in their study showed in 150 persons aged 6 to 30 years, coronary artery lesions were more prevalent in male than in female persons, particularly white male subjects. Although in our study, we did not consider any ethnic variation, the fact that males had more chance of atherosclerosis as compared to females, is consistent with our study results. Notably, the last 2 studies were on non-Indian individuals (these studies were done on the European Population), which on comparative analysis of Indian studies including the present study shows that, atherosclerotic changes are more in Indians than the non-Indians belonging to same age cohort.

## Conclusions

The study showed high prevalence of atherosclerosis in India. Our study adds valuable data regarding the morphology of atherosclerotic lesions as the pathological study of human atherosclerotic lesion is extremely difficult in a living subject and autopsy study is the best possible way. There is no data pertaining to the morphology of the disease in this part of the country. Though our study involved only a small number of cases, most of our observations were similar to those reported previously. Such studies if done on larger sample, over a larger time frame on a multi-centric basis, the results may be higher yielding and may be applicable for baseline reference value for further study and plan for preventive measures of CAD in this part of the country.

**Ethics clearance:** A prior approval was obtained from the Institutional Ethics Committee.

**Conflict of interest:** None to declare

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ORIGINAL ARTICLE

# Comparison of cardiac troponin in postmortem blood sample of sudden cardiac death and non-cardiac death

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**Abstract**
Sudden Cardiac Death (SCD) contributes to 80 % of sudden deaths. Postmortem diagnosis based on changes in heart is difficult if death occurs at an early stage. Estimation of cardiac Troponin I would be useful. Present study was to find out cTn I level in post-mortem blood sample. This cross-sectional study was conducted on 55 cases of cardiac death and non cardiac death with comparison between groups for a period of one year after Institutional Ethics Committee clearance. During autopsy, blood samples were collected and Troponin I estimation was done. Association between the variables were checked using Chi-square test for qualitative variables and student 't' test for continuous variables. Serum Troponin I level among Cardiac Death was 11.1 (SD 13.3) while it was 0.8 (SD 0.7) in Non-Cardiac Death. Optimum cut off value of Troponin I was >1.1 ng/ml with a sensitivity of 98.18 and specificity 87.27. The variation in Troponin I values were significantly different in both groups. Serum Cardiac Troponin I was found to be a good predictor of the SCD.

**Keywords**
Sudden Cardiac Death (SCD); Non Cardiac Death (NCD); Cardiac Troponin I (CTn I); Coronary Artery Disease (CAD); Myocardial Infarction(MI); Body Mass Index (BMI)

## Introduction

Sudden cardiac death (SCD) is the unexpected natural death in a person due to cardiac causes within a short period of time from the onset of symptoms without any prior fatal disease.[1] SCD constitutes 60-70% of sudden deaths[2] of which acute myocardial ischaemia (AMI) due to coronary artery disease (CAD) accounts for 45 to 90% of deaths.[3, 4] Post-mortem demonstration of AMI is based on conventional gross and histological changes which occur 8 hours after coronary occlusion. The important histological changes are; waviness of myocardial fibres (89%), inflammatory cell infiltration (10 -66 %), haemorrhage (8%), cellular oedema (10%), necrosis (90%) and vascular proliferation (8-40%).[5]

The limitations of autopsy in the diagnosis of death due to ischemic heart disease are well known. When death occurs at a very early stage of infarction, lack of outstanding features at autopsy, presence of nonspecific lesions and the difficulty inidentification of myocardial lesions by traditional macroscopic examination or routine histological stains make it difficult to explain the cause of death. In clinical practice, simple reliable biochemical assays of several biochemical markers like Creatine Kinase, Creatine Kinase- MB, Myoglobin and Troponins are used in the diagnosis of AMI. Among these Cardiac Troponins (cTn) are more specific for myocardial damage and evolved to be the standard biochemical marker.[6] CTn is released in circulation in response to myocardial damage and persists in blood up to 2 weeks.[7] Elevated levels of Cardiac troponin can be used to diagnose myocardial infarction. In Forensic Medicine practice, there is a need for more sensitive diagnostic methods like Troponin assay for post-mortem diagnosis of myocardial damage. Troponin assay could serve as a laboratory confirmation of myocardial damage in cases of sudden death in the absence of any change.[8] Studies about use of cTn have not been conducted so far in Kerala. Due to the increasing number of sudden cardiac deaths followed by increasing autopsies of the same, there is an increased demand for such an easy and early method to identify the sudden cardiac death. In this scenario the present study aims to find out whether cardiac Troponin I level in the post-mortem blood sample is elevated and can be used as a diagnostic marker of sudden cardiac death.

## Materials and Methods

This cross sectional study with comparison between groups was conducted in Department of Forensic Medicine, State Medicolegal Institute, Medical College, Thiruvananthapuram. Sample size was calculated as 55 in each group. Dead bodies of adults aged above 18 years brought for medicolegal autopsy with history of death due to sudden cardiac causes were included in the study group. Decomposed bodies, unknown

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bodies and other associated cause for death were excluded. For comparison of cTn I value another group of non-coronary death (NCD) was formed which included those dead bodies in the age group of 18 to 40 years with history of death due to non-cardiac causes and without any cardiac or renal problems.

The police officers and relatives were interviewed. During post mortem examination, all internal organs including heart was examined in detail regarding gross changes of myocardial damage and 5 ml of blood sample from neck veins was collected in anti-coagulated bottle. Immediately after post mortem examination, the blood sample was sent for analysis of serum level of cTn I to Advanced Clinical Research Laboratory, Medical College, Thiruvananthapuram. The reports were obtained within two to three hours. The values were measured in ng/ml unit. All the information obtained was recorded in the proforma prepared for data collection.

Statistical analysis was done using Statistical Package for Social Sciences SPSS 21.0 version. Association between the variables was checked using Chi-square test for qualitative variables, and, student 't' test for continuous variables. A p - value of < 0.05 was considered statistically significant. In order to find out the diagnostic predictive value of cardiac troponin, analysis was done. All the 110 cases of SCD and NCD were pooled together and Receiver Operated Characteristic (ROC) curve was plotted to find out the diagnostic cut off value with maximum sensitivity and specificity. From the plotted ROC curve, the sensitivity and specificity of cTn I as a diagnostic tool to predict acute myocardial infarction for various values of cTn I was found out. From all values the optimum cut off value with maximum sensitivity and specificity were selected. This value was taken as diagnostic cut off value to predict AMI with maximum sensitivity and specificity.

## Results

The mean age of the total population was 40.3 years (SD 16.01), whereas it was 52.2 (SD12.5) and 28.4 (SD 8.6) in cases of Sudden Cardiac Death (SCD) and Non Cardiac Death (NCD) respectively Table 1.

**Table 1:** Descriptive analysis for the age and BMI in SCD versus NCD cases

| Variable | Category | Mean | SD | t | p value |
|---|---|---|---|---|---|
| Age | SCD | 52.2 | 12.5 | 11.619 | 0.001 |
| | NCD | 28.4 | 8.6 | | |
| BMI | SCD | 24.1 | 3.6 | 2.764 | 0.007 |
| | NCD | 22.5 | 2.0 | | |

SCD - Sudden Cardiac Death; NCD - Non Cardiac Death; SD - Standard deviation

The average height was 162.1cm (SD 9.7) in SCD against 163.6 cm (SD 8.2) in NCD. The mean weight among SCD was 63.9 Kg (SD14.2) and in NCD 60.6 Kg (SD 8.6). The Body Mass Index (BMI) showed a mean value of 24.1 (SD 3.6) in SCD and 22.5 (SD 2.0) in NCD [Table 1]. Both age and BMI showed a statistically significant difference ($p < 0.05$). Males formed the majority in both groups Table 2.

**Table 2:** Sex distribution among two groups

| Gender | SCD | | NCD | | Total | | $\chi^2$ | df | p value |
|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | | | |
| Male | 41 | 74.5 | 39 | 70.9 | 80 | 72.7 | 0.183 | 1 | 0.669 |
| Female | 14 | 25.5 | 16 | 29.1 | 30 | 27.3 | | | |
| Total | 55 | 100 | 55 | 100 | 110 | 100 | | | |

SCD - Sudden Cardiac Death; NCD - Non Cardiac Death; df – Degrees of freedom

Morphological characteristics of the heart like weight, left ventricular thickness and percentage of narrowing of coronary arteries were more in cases of SCD Table 3.

**Table 3:** Morphology of heart in SCD versus NCD cases

| Variable | Category | Mean | Standard deviation | t | p value |
|---|---|---|---|---|---|
| Weight of heart (g) | SCD | 339.36 | 78.4 | 7.9 | 0.001 |
| | NCD | 255.6 | 17.11 | | |
| LV thickness (cm) | SCD | 1.87 | 0.3 | 7.99 | 0.001 |
| | NCD | 1.56 | 0.11 | | |
| Narrowing of coronary Arteries (%) | SCD | 86.55 | 21.94 | 21.51 | 0.001 |
| | NCD | 15.45 | 10.94 | | |

SCD - Sudden Cardiac Death; NCD - Non Cardiac Death; SD - Standard deviation

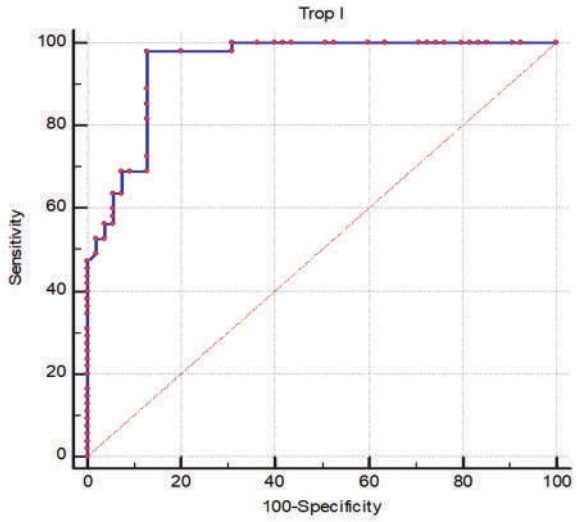
The mean value of Trop I in SCD was 11.1 ng/dl (SD 13.3) and in NCD 0.8 ng/dl (SD 0.7). This difference is highly statistically significant with a p value <0.001. The mean value of Trop I in whole study population (in 110 cases of both SCD and NCD together), when analyzed, was found to be 5.95 ng/ml (SD 1.07) Table 4.

**Table 4:** Comparison of Serum Troponin I level in SCD versus NCD cases

| Group | Mean (ng/ml) | Standard deviation | t | p value |
|---|---|---|---|---|
| SCD | 11.1 | 13.3 | 5.787 | 0.001 |
| NCD | 0.8 | 0.7 | | |
| Total | 5.95 | 1.07 | | |

SCD - Sudden Cardiac Death; NCD - Non Cardiac Death

The optimum diagnostic cut off value of Trop I is > 1.1ng/ml with a sensitivity of 98.18 and specificity 87.27% (Fig. 1).




| Area under curve (AUC) | 95% CI of AUC | Optimum cut of value of cTn I | Sensitivity | Specificity |
|---|---|---|---|---|
| 0.947 | 0.887-0.981 | >1.1 ng/ml | 98.18 | 87.27 |

**Fig 1:** Receiver Operated Characteristic (ROC) curve plotted for Trop 1 value among study population (N=110)

## Discussion

Present study showed a male predominance in groups, 74.5% and 70.9% respectively similar to various other studiesin Kerala and USA.[9,10] The mean age of deceased of sudden cardiac death is 52.2 years (SD 12.5) as in agreement with previous study where the mean age was 47 years (SD 13).[10] Among non-cardiac deaths, mean age was 28.4 years (SD 8.6). Body mass index showed statistically significant difference between the groups with a mean BMI among SCD and NCD of 24.1 (SD 3.6) and 22.5 (SD 2.0) with a p value 0.007.

The mean value of Trop I in cases of SCD was 11.1 ng/dl (SD 13.3) and in NCD0.8 ng/dl (SD 0.7). This difference is highly statistically significant with a p value <0.001. In a study by Patel, positive Trop I test (Trop I >0.04ng/ml) was observed in none of the cases of non-cardiac death (control group), but positive test was observed in 93.8% cases of Sudden cardiac death.[8] Sethi et al in a meta-analysis found out cut off value to be 0.867, whereas Sharma et al stated a positive value as 0.1 to 1 µg/dl.[11] In the study of Martinez et al it was observed a mean value of Trop I as 11.8 (SD 23.6).[12]

Pooling 110 cases consisting of 55 SCD and 55NCD, Receiver Operated Characteristic Curve was plotted to assess the optimum cutoff value to predict cardiac death. The area under the curve is 0.947 with 95% Confidence Interval of 0.887 to 0.981. The optimum cut off value of Trop I is > 1.1ng/ml with a sensitivity of 98.18 and specificity 87.27%. In the meta analysis and systematic review on diagnostic accuracy of high sensitive troponin on MI, by Sethi et al.,[11] pooled sensitivity and specificity of all high sensitivity Trop I studies at a 99th percentile cut off were 0.867 (95%CI:0.845-0.887). Commonest site of occlusion was proximal part of Anterior Descending Artery (49.1%), followed by upper and lower halves of Right coronary artery (30.9% each). It was well reported in literature that proximal 2 cm of LAD is the commonly affected part of coronary arteries[13] followed by right coronary artery (24 to 46%).[14]

## Conclusions

The first microscopic change will appear at least 6 hours after myocardial ischaemia. In these cases, a simple and rapid assay of serum cTn I will help to arrive at a diagnosis of SCD. This can be implemented and can reduce the load and expense of work in mortuary and pathology department. An opinion can be given at an early date without waiting for pathology report so that the investigating agency can act accordingly and to end unnecessary suspicion and rumors in air.

The limitation of this study is that the group of NCD was planned and selected based on the status of their cardiac status as normal. This type of grouping might have produced a bias and might have resulted in high sensitivity and specificity as observed in this study. Even then this can be used as a diagnostic marker for myocardial damage.

**Ethical considerations:** The study was initiated after approval from Institutional Research Committee (IRC) and Institutional Ethics Committee (IEC). This study was funded by State Board of Medical Research (SBMR), Medical College, Thiruvananthapuram. Informed written consent was obtained from the accompanying near relative.

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ORIGINAL ARTICLE

# Patterns of homicidal deaths in population of western Uttar Pradesh

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**Abstract**
Homicides are common cause of loss of human lives since ancient times. This study was conducted to find out the method, cause and circumstances causing homicidal deaths in present era, especially in Northern Uttar Pradesh. A total of 227 homicidal deaths were studied for epidemiological and medico-legal aspects in dead bodies brought to the mortuary of LLRM Medical College, Meerut for medico-legal autopsies between June 2017 to October 2018. All the data thus collected was compiled and analysed in detail. The majority of the victims (70.92%) were males, and young adults (60.34%) between 21–40 years of age. Sharp edged weapons (50.66%) and firearms (29.96%) were used in the majority of the homicidal victims. Assailants had tried to hit on vital areas in almost all the cases, of which multiple areas were involved in more than 2/3rd (69.61%) of the cases. Head was the commonest individual body part involved in 18.06% cases of homicides. Haemorrhage and shock were the most common cause of death (62.99%) and disputes on money and/or property remained the most important reason behind the homicides (23.34% cases).

**Keywords**
Homicide; Firearms; Sharp-edged weapon; Shock; Haemorrhage; Disputes on property.

## Introduction

Homicide is one of the most atrocious crimes since early civilization. It is defined as "Killing of one person by another" in Oxford English dictionary. As per National Crime Record Bureau, Ministry of Home Affair, Govt. of India, 30,450 people were killed in 2016 which is comparatively less than the homicides in 2015,[1] but still alarming. State-wise, 16% (4,889 cases) of the homicidal deaths occur only in Uttar Pradesh followed by Bihar (8.5%) and Maharashtra (7.6%).[2] Meerut is in no way lagging behind this national data. Besides personal vendetta, property dispute and love affairs murders occur in this region in the name of honor killing. Communal riots and other socio-religious factors also contribute homicidal deaths. That's why; this study has been taken to find out the reason behind such deaths and if possible suggest some measures to reduce crime.

## Materials and Methods

The present study was conducted in the Department of Forensic The materials for the present study were the cases brought to the mortuary of Lala Lajpat Rai Memorial Medical College, Meerut with alleged history of murder during the period from June 2017 to October 2018. After thorough investigation, if the cases were found accidental or suicidal, they were excluded from this study. In the same way, if a suicidal or accidental death turned out to be homicidal, they were included. The epidemiological data regarding age, sex, type of weapon used and motive behind homicide was gathered from police papers and questionnaire with accompanying police officers or relatives/friends accompanying the dead body. Injuries and cause of death were collected from post-mortem reports. All the data thus collected was analyzed and results are presented in tabular form and figures.

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## Results

During June 2017 to October 2018,2226 autopsies were conducted at district mortuary of LLRM Medical College, Meerut of which, 227 cases were homicidal which constitutes 10.19% of total unnatural deaths. The majority of the victims were males (N=161, 70.92%) than females (N=66, 29.07%). Male: Female ratio was 2.3:1. The victims were aged from few hours to 91 years, however, the maximum number of cases were in the 21 – 30 years of age group (36.13%) followed by 31–40 years (24.22%). The preponderance of males over females was seen in all the age groups except in children below 10 years where females were more common victims of homicide Table 1.

**Table 1:** Age and sex distribution of victims of homicidal deaths

| Age | Males (%) | Females (%) | Total (%) |
|---|---|---|---|
| 0-10 | 03 (1.32) | 05 (2.20) | 08 (3.53) |
| 11-20 | 19 (8.37) | 09 (3.97) | 28 (12.34) |
| 21-30 | 55 (24.23) | 27 (11.89) | 82 (36.13) |
| 31-40 | 38 (16.75) | 17 (7.49) | 55 (24.22) |
| 41-50 | 22 (9.69) | 02 (0.88) | 24 (10.57) |
| 51-60 | 16 (7.04) | 03 (1.32) | 19 (8.37) |
| 61-70 | 05 (2.20) | 02 (0.88) | 07 (3.08) |
| 71-80 | 02 (0.88) | 00 (0.0) | 02 (0.88) |
| 81-90 | 00 (0.0) | 01 (0.44) | 01 (0.44) |
| > 90 | 1 (0.44) | 00 (0.0) | 01 (0.44) |
| Total | 161 (70.92) | 66 (29.07) | 227 (100) |

Against the popular belief, most of the homicidal deaths (82.81%) occurred away from victim's and accused's place. Only 10.13% victims were killed at their home and 7.04% in accused's territory. The evidence of disposal of dead body on

railway tracks, outskirt areas, water reservoirs etc. to tamper out the evidences is seen in 43.17% cases. Maximum, 1/3rd of the killings (33.92%) occurred in late night and least (8.82%) in 6 PM to 12 midnights (Fig.1).

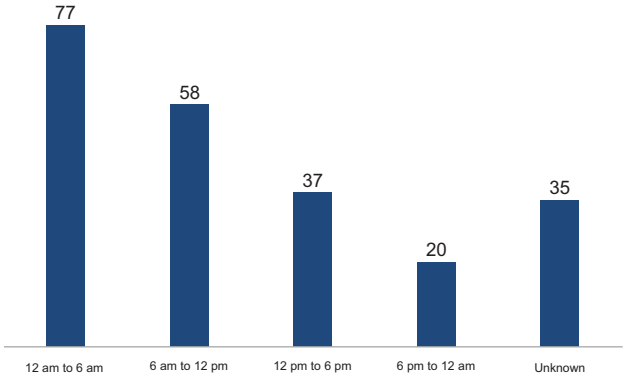


**Fig. 1:** Time of occurrence of homicides

Sharp weapons alone or in combination with blunt weapons were used to kill majority (50.66%) of the homicidal deaths. As a single weapon, Firearms were used more often in 29.96% cases. 13.64% of the victims, mostly females, were killed by asphyxiation (Strangulation/smothering) as shown in Table 2.

**Table 2:** Type of weapon used

| Injury | Males (%) | Females (%) | Total (%) |
|---|---|---|---|
| Sharp/Pointed | 38 | 13 | 51 (22.47) |
| Blunt | 11 | 02 | 13 (5.74) |
| Both sharp & blunt | 47 | 17 | 64 (28.19) |
| Firearm | 57 | 11 | 68 (29.96) |
| Asphyxia (Manual/Ligature) | 09 | 22 | 31 (13.64) |
| Total | 161 | 66 | 227 (100) |

Two new born were also in this study and both were killed by smothering.

In most of the cases (66.07%), multiple injuries involving vital areas over different body parts were seen in victims. Chest and abdomen together were the most vulnerable part injured in about half (49.33%) of the victims of homicide followed by head in 18.06%, neck in 6.63% and abdomen and chest individually in 5.28% and 3.97% respectively Table 3.

**Table 3:** Body parts involved

| Body Parts | Number | Percent |
|---|---|---|
| Head only | 41 | 18.06 |
| Neck only | 15 | 6.63 |
| Abdomen only | 12 | 5.28 |
| Chest only | 09 | 3.97 |
| Chest and Abdomen | 112 | 49.33 |
| Abdomen, pelvis and lower limbs | 19 | 8.37 |
| Head, neck and chest | 12 | 5.28 |
| Multiple places all over | 07 | 3.08 |
| Total | 227 | 100 |

Almost all the victims of homicidal deaths (90.31%) died at the spot or on the way to the hospital without any treatment. Shock and haemorrhage was the most common cause of death seen in 62.99% cases, followed by coma due to head injury in 22.91% and mechanical asphyxia in 13.66% cases. The only case (0.44%), who survived for 5 days, died due to septicaemia from infected wound Table 4.

**Table 4:** Cause of death

| Cause | Number | Percent |
|---|---|---|
| Shock and hemorrhage | 143 | 62.99 |
| Coma due to head injury | 52 | 22.91 |
| Mechanical asphyxia | 31 | 13.66 |
| Septicemia | 01 | 0.44 |
| Total | 227 | 100 |

Disputes on money, land or property was the commonest reason behind the homicidal death found in 23.35% cases followed by murder in sudden rage (19.38%) and familial/personal rivalry (11.46%). Females (6.60%) were killed in family quarrel due to marital disharmony, dowry or illicit relationship. The motive behind the killing could not be ascertained in 1/3rd (33.48%) cases Table 5.

**Table 5:** Motive of homicide

| Duration | Number | Percent |
|---|---|---|
| Financial/Property disputes | 53 | 23.35 |
| Killing in rage | 44 | 19.38 |
| Familial/Personal rivalry | 26 | 11.46 |
| Robbery | 07 | 3.08 |
| Family Quarrel | 15 | 6.60 |
| Failure in love | 06 | 2.65 |
| Unknown | 76 | 33.48 |
| Total | 227 | 100 |
| | | |

## Discussion

The majority of the victim are males as reported in more than 2/3rd (70.92%) of the homicidal deaths which correspond to the data in other studies done on homicide.[3] It is also observed that large numbers of victims (60.34%) are young adults between 21-40 years of age. This is probably due to their aggressive nature and lead role in financial and property affairs. This also corresponds to the study done in Imphal.[4] As to the place of incidence, majority of the deaths (83%) occurredat a remote unrelated location away from the victim's or accused's house. However, in a study conducted in Bangalore,[5] large number of deaths occurred at victim's house.

Sharp pointed weapon alone or in association with blunt weapons are found the commonest weapon (50.66%)[6] used in murder cases. As a single weapon, firearm is used in as many as 29.96% cases. The high incidence of firearm deaths in this region is due to the easy availability of country-made arms. Similar observations are also found in studies conducted at Mumbai[7]and in England.[8] Though the chest and abdomen were involved in about half (49.33%) of the cases, head was hit the most (42.65%) in deaths due to firearms.[9]

As to the cause of death, shock and hemorrhage is the commonest (62.99%) followed by head injury (22.90%) and mechanical asphyxia (13.66%) which corresponds to the observation made by Nayak GH[10] but Sinha US in allahabad[11] reported head injury as the most frequent cause of death in homicides. It is also observed that dispute on money, land/property is still the commonest motive behind homicidal death seen in 23.35% of the cases. Killing in sudden rage on petty issues and familial/personal rivalry are the reason for high incidence of homicidal deaths. This corresponds to the study conducted at Hubballi[10] and Gujarat.[12]

**Ethical clearance:** A prior approval was obtained from the Institutional Ethics Committee

**Conflict of interest:** None to declare

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ORIGINAL ARTICLE

# Heel-Ball Index - A tool for identification

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**Abstract**

Sex is frequently used as a parameter to identify people. Body dimensions used for estimating sex can aid in the development of a biological profile for the process of identification. This study was conducted on a sample of 112 Indian individuals comprising 56 males and 56 females belonging to an age group of 18 to 22. This study attempts to estimate sex from dimensions and indices using a standard value. The sexual dimorphism of Foot Breadth at Ball (BBAL), Foot Breadth at Heel (BHEL) and Heel-Ball Index (HBI= BHEL/BBAL x 100) were appreciable in both legs. However, we found that employing absolute foot dimensions like BBAL and BHEL to estimate sex produced better results than HBI derived as a ratio of absolute measurements.

**Keywords**

Anthropology; Forensic science; Heel-Ball Index; Stature estimation; Sex determination.

## Introduction

Determination of sex plays a vital role in the determination of individuality of a person because it is one of the four basic parameters of forensic identification.[1,2] It effectively narrows down the search range of identity.[3] Although modern humans have evolved to be less dimorphic than their ancestors, there are still sufficiently measurable morphological differences between sexes in our species.[4] Forensic Podiatry, which emerged in the recent past explores the use of foot measurements for identification. Estimation of sex from foot dimensions becomes important in medico-legal cases involving foot impressions, footprints and mutilated body parts. In many cases, a part of the foot is brought for forensic studies like in cases of mutilation, mass disasters etc. which makes sex estimation complicated. Also, in many cases, estimation of sex from footprints, especially in crime scenes decreases the field of investigation significantly.[5] Estimation of sex from foot dimensions is of great value in forensic sciences, andhence, numerous studies have been conducted in this regard.[6-11] In a study conducted in 2008, it was proved that natural biological variance, population group, sex, BMI, etc. have significant influences on the morphology of an individual's foot.[12]Krishan et al. indicated that foot breadth had better accuracy in sex determination than the foot length.[13] He introduced Heel-Ball index as a new index for estimation of sex using foot breadth dimensions.[5]

## Materials and Methods

The present study was conducted on a sample of 112 Indian individuals comprising 56 males and 56 females belonging to an age group of 18 to 22 years. Basic demographic data like age and gender was collected at the time of data collection. All personal and demographic information is kept anonymous to protect participant privacy. Before measurement, all individuals were asked to wash their feet with soap and water. Subjects were checked for any appreciable foot deformity. All necessary precautions were taken during measurements. Before measuring, the measuring device was checked for accuracy and zero error each time.

The Foot Breadth at Ball (BBAL) and Foot Breadth at Heel (BHEL) of both the legs of these individuals were taken in a well-lit room using standard anthropometric procedures described by Krishan et al.[5] BHEL and BBAL were measured using sliding digital callipers in centimetres to the nearest millimetre.

Heel-Ball index of each foot and footprint was calculated using the formula given below

$$\text{HEEL BALL INDEX} = \frac{\text{BHEL}}{\text{BBAL}} \times 100$$

The data thus collected were entered into MS Excel 2016 and further analysed using Statistical Package for Social Sciences software version 16.0. The mean and standard deviation for BBAL, BHEL and HB index of both right and left foot were calculated separately. Independent t-test /Mann-Whitney U test was applied to determine the difference in statistical parameters between men and women. To determine the effectiveness of HB index, BBAL and BHEL in the determination of sex of an individual, an attempt to derive a cut off value wasmade using the concept of a standard point.

The standard point was derived using the formula, Standard Value = [(Mean male value - SD) + (Mean female value + SD)]/2 and the accuracy of all the parameters were tested on the study population.

## Results

The participants (56 males and 56 females) in the age group of 18 to 22 years were included in the study. Descriptive statistics including mean, standard deviation, t value and p-value of

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BHEL, BBAL and HBI of left and right foot dimensions of male and female subjects are given in Table 1.

**Table 1:** BBAL, BHEL and HBI from left and right foot dimensions of men and women.

| | Side | Sex | Mean | SD | t | p |
|---|---|---|---|---|---|---|
| Breadth at ball | Left | Male | 10.36 | 0.72 | 12.014 | <0.001 |
| | | Female | 8.66 | 0.77 | | |
| | Right | Male | 10.29 | 0.56 | 14.931 | <0.001 |
| | | Female | 8.80 | 0.50 | | |
| Breadth at heel | Left | Male | 6.68 | 0.51 | 16.595 | <0.001 |
| | | Female | 5.16 | 0.46 | | |
| | Right | Male | 6.66 | 0.55 | 14.347 | <0.001 |
| | | Female | 5.23 | 0.50 | | |
| Heel ball index | Left | Male | 64.16 | 3.51 | 3.716 | <0.001 |
| | | Female | 60.16 | 7.25 | | |
| | Right | Male | 64.26 | 3.46 | 6.122 | <0.001 |
| | | Female | 59.54 | 4.60 | | |

Genderwise distribution of HBI on rigth and left foot is depicted in Fig. 1 and 2 respectively.

**Fig. 1:** Sex distribution of Heel-Ball index on right foot

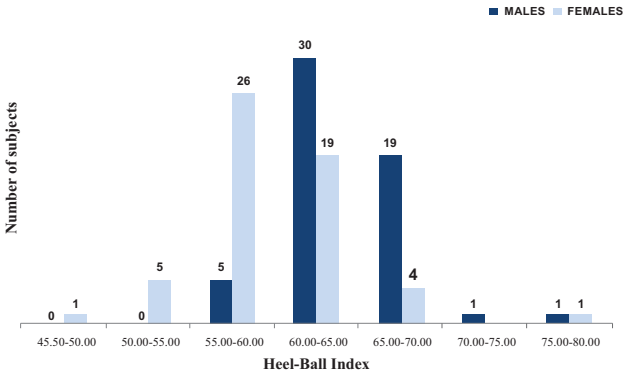
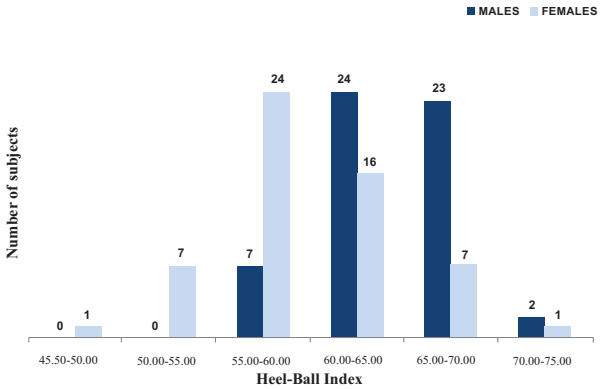



**Fig. 2:** Sex distribution of Heel-Ball index on left foot




On measurements of foot breadths at ball and heel (BBAL and BHEL), it is evident that all measurements are larger in males than in females in both right as well as left foot. The paired t-tests showed that the measurements (breadths at the ball and heel) and heel ball index from foot measurements are significantly larger (p-value<0.001) in males when compared to females.

Table 2 shows standard values derived using mean and standard deviation using the given formula. These values were derived for BBEL, BHEL and HBI of right as well as left foot. These standard values, thus derived, were tested on the study population.

**Table 2:** Standard values for BBAL, BHEL and HBI of direct foot measurements

| Parameter | Left | Right |
|---|---|---|
| Breadth at ball | 9.535 | 9.515 |
| Breadth at heel | 5.895 | 5.92 |
| Heel-ball index | 64.03 | 62.47 |

Table 3 shows the accuracy of standard values when applied to the study population. The percentage of accuracy was also calculated. BHEL and BBAL in both left and right were found to have excellent accuracy (>90%) whereas Heel Ball Index in left, as well as right foot, has a moderate level of accuracy (>70%). This is because significant overlapping was observed in HBI in males and females.

**Table 3:** Accuracy of standard values in foot dimensions

| | Side | Sex | Cases that were correctly identified | Percentage in the study group |
|---|---|---|---|---|
| Breadth at ball | Left | Male (n=56) | 49 | 87.5 |
| | | Female (n=56) | 53 | 94.6 |
| | | Total = 112 | 102 | 91.1 |
| | Right | Male (n=56) | 51 | 91.0 |
| | | Female (n=56) | 53 | 94.6 |
| | | Total = 112 | 104 | 92.9 |
| Breadth at heel | Left | Male (n=56) | 55 | 98.2 |
| | | Female (n=56) | 53 | 94.6 |
| | | Total = 112 | 108 | 96.4 |
| | Right | Male (n=56) | 53 | 94.6 |
| | | Female (n=56) | 52 | 92.8 |
| | | Total = 112 | 105 | 93.7 |
| Heel ball index | Left | Male (n=56) | 30 | 53.57 |
| | | Female (n=56) | 44 | 78.6 |
| | | Total = 112 | 74 | 66 |
| | Right | Male (n=56) | 41 | 73.2 |
| | | Female (n=56) | 42 | 75 |
| | | Total = 112 | 83 | 74.1 |

## Discussion

The significance of sex in the identification of an individual is well established. Anthropometric means are increasingly being used for this purpose. Mutilated body parts and impressions are common in natural calamities, disasters and many crime scenarios.[14,15] Hence forensic experts are in a greater need to develop methods, which make use of dimensions of smaller body parts. Studies of various anthropometric parameters for the purpose of identification have been conducted in the past. In many such anthropometric studies foot dimension has been an important parameter and correlations have been drawn between foot dimensions and stature.[16-20]

Very few attempts have been made to correlate foot dimensions and sex; most of these studies focussed on foot lengths as the anthropometric parameter.[6-12] But Krishan et al. found that foot breadth is a better parameter than foot length.[13]

The standard values derived for Foot Breadth at Ball (BBAL) were found to have excellent accuracy for predicting sex

(>90%). This is consistent with previous studies.[4-13] The standard values derived for Foot Breadth at Heel (BHEL) were also found to have excellent accuracy for predicting sex (>90%) as indicated by previous studies.[4,13] The current study underlines observations from the mentioned studies that all the concerned foot measurements are larger in males than in females ($p<0.001$).

Researchers realised that sexual dimorphism exhibited by foot dimensions are likely to be influenced by stature and build. Several attempts have been made in the past to derive indices that are unlikely to be influenced by these factors. Foot index, used by Moudgil et al.[10] and Krishan et al.[13] as a ratio of foot length and breadth was one such attempt. However, it was found that sex determination could not be made conclusively from foot index. In further studies conducted by Krishan K et al. they derived HB index and observed that this index was independent of weight and stature. In their pilot study, it was found that HB index is larger in women than in men.[5] However, in the present study, HBI was found to be significantly larger ($p<0.001$) in males than females for both the legs. But an overlap of male and female values of HBI is observed, which is more than what was found in dimensions. Also, the standard values derived for HBI showed an accuracy of >70% in predicting sex for both sexes in the right leg and females in the left leg. But, the accuracy of HBI for males in the left leg was found to be very poor (>50%).

This study attempts to estimate sex from dimensions and indices using a standard value. The sexual dimorphism of BBAL, BHEL and HBI were appreciable in both legs. However, we found that employing absolute foot dimensions like BBAL and BHEL to estimate sex produced better results than Heel-Ball Index derived as a ratio of absolute measurements.

## Conclusion

Finding a pattern in anatomical features and drawing conclusions from them is crucial in the identification of individuals. Environmental and genetic factors influence the magnitude of sexual dimorphism of anatomical components. This varies within and between populations. We conclude that this may be the reason for a difference in findings between this study and the previous studies. Since Heel Ball Index is a novel idea, further explorations are required using larger population samples in different communities.

**Ethical clearance:** A prior approval was obtained from the Institutional Ethics Committee

**Conflict of interest:** None to declare

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ORIGINAL ARTICLE

# Audit of medical certificate of cause of death at a tertiary care teaching hospital

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**Abstract**

Medical or medicolegal documents like medical certificate of cause of death (MCCD) are important in view of mortality statistics. Such certificates are inaccurately or incompletely filled then these have adverse impact on health and diseases related statistics. We analysed 278 MCCDs for major errors, minor errors and completeness of information at tertiary care teaching hospital, Navi Mumbai, India. Almost all certificate (100%) had either a major or minor error. We observed at least one major error (244, 87.76%) and minor error (276, 99.28%) in MCCDs. The most common major error was sequencing errors (180, 64.74%), followed by unacceptable cause of death (105, 37.76%). Combination of two major errors was seen in 99 (35.61%) MCCDs and combination of two minor errors were seen in 143 (51.43%) MCCDs. Most common minor error was no mention of time interval (275, 98.92%). Incomplete MCCD was observed in 44 (15.82%) cases and maximum certificate had not commented or mentioned about status of pregnancy/delivery (n=24, 8.63%) in the certificates. In our study most common cause of death as per ICD classification was Circulatory (n=105, 37.76%). Similar studies should be regularly conducted to understand the burden of errors made by clinicians. Even routine audit of MCCDs will help to assess the problem in hospitals. We recommend routine educational workshop to train the clinicians regarding complete and accurate filling of MCCDs.

**Keywords**

Medical certificate of cause of death; Certificate; Major error; Minor error

## Introduction

The medical certificate of cause of death (MCCD) is a legal document of significant importance. It is a primary source of mortality and disease statistics essential for guiding resource allocation for public health programs. It is essential to ensure completion and accuracy of the cause of death section in death certificate as vital statistics related to health, morbidity, mortality and disease prevalence can be derived from it.

The standard cause of death certificate format prevalent in India is based upon the recommendations of the WHO and uses classification of causes of death according to the International Classification of Diseases (ICD). Form no 4 and 4A are used for MCCD in India. The cause of death is entered in two parts. Part I records the sequence of conditions starting with immediate cause of death (the final disease or condition resulting in death) on line (a), which is due to the condition recorded on line (b), which is due to condition recorded on line (c), which is due to the underlying cause of death (the ultimate disease or injury that initiated events resulting in death on line (d). It is not necessary to record information on all lines, but the underlying cause of death should be mentioned last in the sequence. The part II of the certificate requires other significant conditions contributing to death. Usually, the condition recorded in the lowest line of part I is taken as the underlying cause of death and used for statistical analysis of mortality by ICD-10.[1,2]

Errors in cause of death certificate are common and may lead to erroneous data generation. These errors can occur at every step of certification process and may range from incomplete certificate to incorrect causes of death. Some studies had revealed that 24% to 37% of sampled death certificates contain major errors in the causes of death.[3-6]

Studies done in South Africa have also demonstrated high proportions of errors sufficiently serious enough to affect the accuracy and identification of underlying cause of death.[7,8] In India death certification is believed to be very poor and incorrect in most of the health care system.[9] We had undertaken this study to analyze all types errors, which are present in the MCCD issued in our institute.

## Materials and Methods

The study was conducted at DY Patil Hospital, Navi Mumbai, India which is a 1200 bed teaching hospital. The study was conducted over a period of one year from 1 January 2014 to 31 December 2014 where we analysed 278 medical certificate of cause of death made available by the Medical Record Department of the hospital. The MCCD certificates were audited for major errors, minor errors and completeness of information.

Errors which could affect the accurate coding of the underlying cause of death were considered as major, and included; unacceptable cause of death in part 1, listing of mechanism of cause of death in part 1, competing causes of death, sequencing errors (incorrect presentation of order of immediate,

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intermediate and underlying causes of death), or mechanism of death not followed by a proper cause of death. Errors which were less likely to lead miss-classification of the underlying cause of death were considered as minor, and included time interval between onset of the condition and death not mentioned, use of abbreviations, mentioning "with" instead of "due to", illegible writing

MCCD were also evaluated for completeness of information regarding age, sex, status of pregnancy/delivery in case of females, registration number, seal and signature of certifying physician. The data was recorded on a data capture sheet and was then entered in Microsoft excel sheet. The data collected was analysed by using SPSS 19 software.

## Results

Maximum number of cases were seen in more than 60 years (n=84, 30.31%) followed by less than 10 years (n=62, 22.30 %) and 51-60 years (n=60, 21.58%) (Table 1). Male cases were 169 (60.79%) and female cases were 101 (36.33%)

**Table 1:**Age wise distributionof cases as per MCCD (N=278)

| Age (Years) | N | (%) |
|---|---|---|
| Less than 10 | 62 | 22.30 |
| 11-20 | 5 | 1.79 |
| 21-30 | 16 | 5.75 |
| 31-40 | 18 | 6.47 |
| 41-50 | 24 | 8.63 |
| 51-60 | 60 | 21.58 |
| More than 60 | 84 | 30.21 |
| Not mentioned | 9 | 3.23 |
| Total | 278 | 100 |

**Table 2:**Distribution of cases as per types of major errors in MCCD (N=278).

| Major Errors | N | (%) |
|---|---|---|
| Unacceptable cause of death in part 1 | 105 | 37.76 |
| Listing of mechanism of cause of death in part 1 | 55 | 19.78 |
| Competing causes of death | 12 | 4.31 |
| Sequencing errors (incorrect presentation of order of immediate, intermediate and underlying causes of death) | 180 | 64.74 |
| Mechanism of death not followed by a proper cause of death | 49 | 17.62 |

Almost all certificate (100%) had either a major or minor error. At least one major error was observed in 244 (87.76%) MCCDs. The most common major error was sequencing errors (incorrect presentation of order of immediate, intermediate and underlying causes of death; n=180, 64.74%), followed by unacceptable cause of death in part 1 (n=105, 37.76%), listing of mechanism of cause of death in part 1 (n=55, 19.78 %), and mechanism of death not followed by a proper cause of death (n=49, 17.62%) (Table 2). No single major error was seen in 34 (12.23%) MCCD. Combination of two major errors was seen in 99 (35.61%) MCCDs. Combination of three major errors was seen in 24 (8.63%) MCCDs.

At least one minor error was observed in 276 (99.28%) MCCD. Most common minor error was not mentioning of time interval between onset of the condition and death (n=275, 98.92%) followed by mentioning "with" instead of "due to" (n=183, 38.84), use of abbreviations (n=108, 38.84%) and illegible writing (n=28, 10.07%) (Table 3). No single minor error was seen in 2 (0.71%) MCCDs. Combination of two minor errors was seen in 143 (51.43%) MCCDs. Combination of three minor errors was seen in 65 (23.38%) MCCDs.

**Table 3:** Distribution of cases as per types of minor errors in MCCD (N=278).

| Minor Errors | N | (%) |
|---|---|---|
| Time interval not mentioned | 275 | 98.92 |
| Use of abbreviations | 108 | 38.84 |
| Mentioning "with" instead of "due to" | 183 | 65.82 |
| Illegible writing | 28 | 10.07 |

Incomplete MCCD was observed in 44 (15.82%) cases and maximum certificate had not commented or mentioned about status of pregnancy/delivery (n=24, 8.63%) in the certificates. In our study most common cause of death as per ICD classification was Circulatory (n=105, 37.76%) followed by Respiratory (n=42, 15.10%). The unspecified cause of death was 25 (8.99%) due to wrongly written cause of death (Table 4).

**Table 4:** Distribution of cases as per incomplete certificates, other errors and system wise cause of death in MCCDs (N=278)

| Traits | N | (%) |
|---|---|---|
| **Incomplete MCCD** | | |
| No mention of Status of pregnancy/delivery | 24 | 8.63 |
| Age not mentioned | 9 | 3.23 |
| Sex not mentioned | 8 | 2.87 |
| Others | 3 | 1.07 |
| Total incomplete MCCD | 44 | 15.82 |
| **More than one condition written per line** | 93 | 33.45 |
| **ICD 10 Classification** | | |
| Circulatory | 105 | 37.76 |
| Respiratory | 42 | 15.10 |
| Infectious disease | 40 | 14.38 |
| Gastrointestinal | 19 | 6.83 |
| Perinatal | 13 | 4.67 |
| Neoplasm | 12 | 4.31 |
| Genitourinary | 11 | 3.95 |
| Nervous system | 7 | 2.51 |
| Skin and musculoskeletal | 4 | 1.43 |
| Unspecified | 25 | 8.99 |
| Total | 278 | 100 |

## Discussion

Medical certificate of cause of death (MCCD) is an important medical and legal document. If it is written wrongly or incomplete, it had adverse implications on the mortality statistics and claim of insurance by near relative. Nojilana et al. observed that most cases were of more than 65 years (n=336, 39.0%) in MCCDs.[7] Elsie et al. observed that the most common

age group was more than 65 years (29.4%) in MCCDs.[8] They also observed that age group less than 15 years was 8.6%. Patel et al. studied maximum cases in age group of 15-64 years (56%).[10] Dash et al. observed that maximum number of death certificates were issued for patients in the extremes of the age <10 years ($n$ = 42, 27.82%) and in >60 years ($n$ = 46, 30.46%). [11] Raje observed that the most common age group was 1-10 years (n=64) followed by 51-60 years (n=42) in MCCDs.[12] In our study maximum number of cases were seen in more than 60 years (n=84, 30.31%). Our findings were similar to Nojilana et al.[7], Elsie et al.[8] and Dash et al.[11].

**Table 5:** Comparison of frequency of major errors and most common major errors in MCCDs.

| Study | Major error N (%) | Most common type of major error |
|---|---|---|
| Our study | 244 (87.765) | Sequencing errors (incorrect presentation of order of immediate, intermediate and underlying causes of death) (n=180, 64.74) |
| Sehdev et al.[3] | -- | "mechanisms" as the immediate cause of death (34%) |
| Selby et al.[4] | 36 (37%) | Use of a nonspecific diagnosis (61%) |
| Prittet al.[6] | 48 (96%) | Major missed comorbidities contributing to death |
| | | Major missed component of Part I (immediate or |
| | | intermediate cause (30%) |
| Nojilana et al.[7] | (32.2%) | Serious major error: No acceptable underlying COD (n=170, 17.3%) |
| | -- | Other major error: Improper sequencing (n=236, 24.0%) |
| Elsie et al.[8] | 366 (43.4) | Sequencing errors (n=242, 28.7%) |
| Shantibala et al.[9] | 38.3% | Mechanism of death mentioned as COD (21.9%) |
| Ganasva et al.[13] | 81.5% | Listing the mechanism of death without an underlying disease as the COD (n=1325, 69.6%) |
| Haque et al.[14] | -- | Grade V error (Underlying cause of death was incorrectly attributed or placed in an improper sequence, n=176, 87%) |
| Patel et al.[10] | 23(57.5%) | Improper sequencing (55%) |
| Dash et al.[11] | -- | Inaccurate description of mode of death as immediate cause of death (n=40, 26.49%) |
| Raje MG[12] | -- | Mechanism of death (n=211, 60 %) |
| Akakpo et al.[15] | 191 (56.68%) | Sequence errors (n=159, 83.25%) |
| Bhat et al.[16] | 86 (82%) | The antecedent cause not mentioned in 32 certificates. |
| Myers et al.[17] | 48(32.9%) | Mechanism listed as the underlying cause of death (n=23, 15.8%) and Improper sequencing (n=23, 15.8%) |
| Pandya et al.[18] | 39.6% | Improper sequencing (25%) |
| Azim et al.[19] | -- | Unacceptable underlying cause of death (n=74, 98.6%) |

Comparison of frequency of major errors and most common major errors were given in Table 5. Numbers of major errors or at least one major error in our study were comparable to Pritt et al.[6], Ganasva et al.[13] and Bhat et al.[16]. The most common type of major error was sequence error in our study as well as other studies[7,8,10,15,18]. Numbers of minor errors or at least one minor error in our study were comparable to Nojilana et al.[7], Elsie et al.[8], Shantibala et al.[9], Bhat et al.[16] and Myers et al.[17]. The most common type of minor error was no time interval mentioned in our study as well as other studies[7,-11,16-19](Table 6).

Haque et al. observed that 2 (1%) death certificates had no errors. One hundred fifty-six (77%) certificates had 3 or more errors of varying grades.[14]Patel et al. noticed that all 40 death certificate had errors.[10]In our study all certificate had either major or minor errors. Elsie et al. observed only 70 death notification form (DNF) were free of any errors, meaning that 774 (91.7%) had at least one major or minor error.[8] Bhat et al. found that sixty-three (60%) certificates contained combination of major and minor errors.[16] Multiple errors were common, with 82% containing errors from more than 1 category.[6] Akakpo et al. had observed that non-specialist medical officers had done more errors in certificates as compared to specialist medical officer.[15]

**Table 6:** Comparison of frequency of minor errors and most common minor errors in MCCDs.

| Study | Minor error N (%) | Most common type of minor error |
|---|---|---|
| Our study | 276 (99.28%) | Time interval not mentioned 275 (98.92%) |
| Nojilana et al.[7] | 967 (98.4%) | Absence of time interval (n=967, 98.4%) |
| Elsie et al.[8] | 774 (91.4%) | Time estimate absent (n=688, 81.5%) |
| Shantibala et al.[9] | 77.6% | Time intervals (65.3%) |
| Patel et al.[10] | -- | Time interval (92.5%) |
| Dash et al.[11] | -- | Time interval was missing (n=94, 62.25%) |
| Bhat et al.[16] | 81(77%) | No time interval (n=78) |
| Myers et al.[17] | 123 (84.2%) | No time interval (n=101, 69.2%) |
| Pandya et al.[18] | -- | No time interval (n=28, 29.2%) |
| Azim et al.[19] | -- | No time interval (n=75, 100%) |

Nojilana et al. studied that errors were sufficiently serious to affect identification of underlying cause of death in almost a third of the DNF, confirming the need to improve the quality of medical certification.[7] Raje attributes causes of these errors (99%) were lack of training and diagnostic difficulty. Several errors were found in non-medical part which highlight 'routine attitude' of certifier.[12] Bhat et al. concluded that high number of errors were due multiple co-morbid conditions in a patient, lack of proper training to medical professionals, and heavy work load.[16]

Sehdev et al. studied 494 death certificates out of that improperly completed cause of death (COD) were 204 (41%). COD was improperly completed by clinicians in 191 cases and pathologists in 27 cases.[3] Selby et al. observed the most common error was the use of a nonspecific diagnosis as the underlying cause of death (22 of 36 errors, 61%).[4] Jordan et al. observed that 68.1% of death certificates were filled out in an acceptable manner. They found that on comparing 6 major departments there was significant difference in the error rates of each departments (p = .0035).[5]

Raje studied 353 death certificates and he observed that 21% death certificates were incompletely written and 99% certificates were incorrectly written.[12] Swift et al. studied 1000 completed certificate out of that only 55% of certificates were completed to a minimally accepted standard. Many of these failed to provide relevant information to allow adequate ICD-10 coding. About 10% were completed to a poor standard.[20] Bhat et al. analysed 104 certificates, only 19 (18%) were found to be completely filled and correct.[16] Dash et al. observed that 40 (26.49%) cases had inaccurate cause of death, incomplete

antecedent cause of death (n=35, 23.18%) and incomplete underlying cause of death (n=84, 55.63%).[11] In our study, incomplete MCCD observed in 44 (15.82%) cases and the unspecified or incorrect cause of death was in 25 (8.99%) cases (as per ICD 10). Nojilana et al. studied that most common underlying cause of death was neoplasms (n=287, 29.2 %) followed by circulatory (n=243, 24.7%).[7] Patel et al. observed that the most common underlying cause of death was infectious disease (40 %).[10] In our study most common cause of death was circulatory as per ICD 10 classification.

Few interventional studies were referred for understanding whether educational intervention may improve writing medical certificate of cause of death or not. Accordingly, Myers et al. observed that following the intervention the major error rate decreased to 15.7% ($p = 0.01$). The reduction was also observed in mentioning mechanism of death without a legitimate underlying cause of death from 15.8% to 4.8% ($p = 0.01$).[17] Pandya et al. observed after the educational intervention, there was a significant decrease in major errors such as unacceptable underlying cause of death from 39.6% to 24.5% ($p = 0.034$). They also reported reduction in mentioning mechanism without underlying cause of death from 13.5% to 1% ($p = 0.001$).[18] Azim et al. observed reduction in major errors like mechanism without underlying cause of death (from 60.0% to 14.6%, $p < 0.001$) and competing causes (from 88.0 % to 13.3%, $p < 0.001$).[19]

## Conclusion

The current study revealed significant errors, wrongly written cause of death (COD), and incomplete MCCDs. These errors have significant impact on analysis of COD and subsequently will affect mortality statistics. As it is known that death certificates (MCCDs) are the only source of data on cause of death, the information mentioned in it must be accurate as much as possible. Every medical institution should ensure a system of review and feedback to the certifying doctors regarding accurate and complete filling of these certificates. Hospital administration must conduct educational workshops to train and educate physicians for correct documentation in cause of death certificates as they have been found to reduce the rate of errors.

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REVIEW ARTICLE

# Perspectives about voiceprints

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**Abstract**
Forensic literature often claims "voiceprints" as an acceptable way to carry out forensic speaker identification. However, that assertion does not seem valid. Many advances in the area of speaker identification (SI) have occurred during the past five decades. Hence, it would appear useful to provide both a historical review and current perspectives of the "voiceprint" issue. The review also discusses other more advanced approaches to speaker identification, and provides a brief overview of the efficacy and future prospects of these newer approaches to speaker identification.

**Keywords**
Voiceprints; Spectrogram; Speaker Identification

## Introduction

"Voiceprints" are a phenomenon which emerged just after World War II – and, primarily in the United States. This approach involved comparing a visual print (voiceprint) of an unknown speaker's speech sample with that of a suspect's exemplar in order to determine if they were produced by one speaker or two. The task involved identifying similarities and dissimilarities in the acoustic patterns in the time-frequency-amplitude (t-f-a) spectrograms based on visual inspection (Fig. 1).

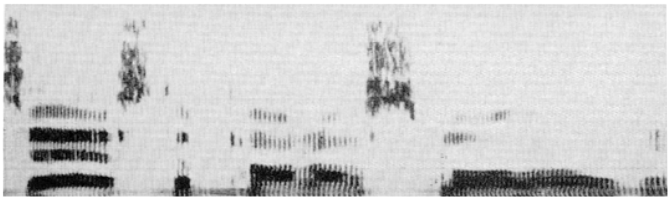

**Fig. 1:** Time-frequency-amplitude spectrogram. From Hollien [22]. A Printout of a time-frequency-amplitude spectrogram (Sonagram) of the type used as a basis for "voiceprints". As can be seen, the bars result from vowels (their formants) and the vertical noise bands from consonants (mostly fricatives). Time is along the horizontal axis, frequency the vertical and amplitude (or sound energy level) the darkness of the markings. "Voiceprinters" attempt to find similarities (or differences) in the patterns on this type of spectrogram.

Of course, in the beginning, their use in law enforcement and the courts was virtually unopposed. Afterall, it was during that period that criminal justice personnel began to badly need ways to identify perpetrators from their voices. In any event, the number of cases of this type grew rapidly. This view was further strengthened by a paper entitled "Voiceprint Identification"[1] in which the author wrote, "My claim to voice pattern uniqueness then rests on the improbability that two speakers would have vocal cavity dimensions and articulatory patterns identical enough to confound voiceprint identification methods." However, two types of competition quickly developed in the speaker identification (SI) area. First, aural-perceptual speaker identification (AP SI) was being developed by some Phoneticians (usually at the faculty level of a university). Second, some electronic approaches to SI were being studied -- mostly by engineers. However, during those early years, the approaches applied by these two groups tended not to be particularly effective. Hence, the SI area remained rather unstructured. More recently, however, extensive (and remarkable) advances in relevant technology have occurred. They have upgraded the voice recognition area and have long since left "voiceprints" as a failed approach.

Yet, three articles -- urging the use of "voiceprints" -- have been recently published in Indian journals. All have attempted to provide an overview of speaker identification and some of the specifics about "voiceprints." They appeared to believe that they had discovered a long-lost answer to the "SI problem." However, none of them succeeded in providing either a cogent historical review of "voiceprints" or a reasonable description of it as an SI technique. Nor did they appear to tap into the extensive corpus of literature about its mechanisms and/or lack of effectiveness.

For example, the first author of these three articles[2] obtained most of his material from second and third-hand sources; he especially relied on a book by Yount.[3] As a result, his article suffered from a number of errors and items of misinformation. To illustrate: the author did not properly identify 1) who at Bell Telephone Laboratories invented the Sonagraph (that provides the "voiceprints"), 2) when "voiceprints" were first attempted and 3) that even "properly trained" examiners actually could not achieve very high accuracy with the technique. Indeed, in his enthusiasm, he provided the type of statements ordinarily made by "salesmen" but very little of the information contained by the many relevant studies available.

The second article,[4] also was supportive of the procedure and provided a slightly better reference list. However, the author's text is even more generalised and she confused other SI techniques with "voiceprints" to a greater extent than did any

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other of the cited authors; nor does she offer any specific data supporting her position.

On the other hand, three individuals collaborated to create the third of these articles.[5] Although this group provided better references than did the others, they still failed to provide the basic information necessary to understand the "voiceprint" approach. On the other hand, they did provide illustrative material about an actual case. Unfortunately, however, their presentation appeared rather confused. For instance, they indicated that their operational "standards" involved not just that "the minimum sample size (examined) should be of 60 seconds," but also that the "properties of the voice" and the "characteristics of available instruments" should be considered. Further, their analysis of heard stimuli included "consonant formation" as well as whatever is meant by "striking time" and "delivery of speech." On the other hand, they did not include any meaningful analysis of the rather important identification vector of fundamental frequency (Fo). Nor were other elements of the analysis protocol adequately covered. For example, the actual samples that were analyzed were not described.

Finally, this group of authors provided copies of the five pairs of the time-frequency-amplitude (t-f-a) spectrograms they used (as created by the Sonagraph). They did so, apparently in an effort to demonstrate: 1) how "voiceprints" work, 2) how the t-f-a spectra are analyzed and 3) how they were used in an actual case. Unfortunately, however, they were unable to do these things. All they were able to do was exhibit how difficult it is to extract useful information of any kind from the rather fuzzy and irregular lines/bars found on that type of printout. In short, the illustration they used demonstrated that, while the proponents of the system do not lack enthusiasm for it, the system itself seriously lacks the ability to provide data that can be useful in identifying speakers from speech/voice analyses.

## History of "Voiceprints"

The initial research thrust that ultimately gave birth to voiceprints was one initiated by Alexander Graham Bell. He was motivated both to attempt to transmit sound over distance and to create ways of making speech "visible." Subsequently, Bell Telephone Laboratory (BTL) was established whose primary goal was to carry out research designed to make telephones both cheaper and better. However, as a parallel goal, he insisted that the BTL scientists attempt to develop systems and equipment which would make speech "visible." It took years to accomplish this goal, but one of the teams at BTL successfully invented a visible speech device. They called it the Sonagraph.[6,7]

The Sonagraph displays three dimensions: time, frequency and amplitude (t-f-a as it is commonly referred to). While time is displayed on the x-axis, frequency is represented on the y-axis. The darkness of the markings approximates the relative amplitude (within the channel) allowed to pass by the system's filters. Of these three dimensions, time is the most reliable followed by frequency measures. Probably, the most unreliable feature is the 'intensity patterns.' Thus, it is likely that the intensity patterns can be modified (either accidentally or volitionally) and/or misinterpreted easily.

The "voiceprints" procedure described above was in use for a number of years and for a variety of purposes. However, its use in speaker identification did not start until long after Potter[6] published his article entitled "Visible Patterns of Speech" (which also described the device that created the visual spectrogram). Although scattered attempts were made to employ t-f-a analysis in identifying speakers, very few of these early investigators seemed convinced that t-f-a type printouts could be used for stand-alone speaker identification (SI) as speech/voice simply was too complicated, and that the variables were too numerous.

Years later, in an attempt to counter the then existing belief about the fallibility of t-f-a technique, Kersta[1] published his cited paper "Voiceprint Identification," in which he argued that voiceprints were as unique and reliable as fingerprints. However, fingerprints are relatively static in nature. The patterns vary but little over a person's lifetime. On the other hand, human voice is a varying entity. Indeed, the variables here number in the hundreds – perhaps, even, in the thousands. They include numerous differences that are 1) physical in nature: i.e. due to the person's age, size, gender, physiology, auditory sensitivity, intelligence, etc., 2) behavioral: i.e. psychological states, current emotions, stress, fatigue, intent, reason for speaking, etc., 3) the result of the situation: i.e. conflict, threats, criminal activity, etc., 4) environmental: i.e. noise, acoustics, signal distortion, limited channel, etc., in addition to many others. However, owing to very low error rates (1%) in the experiment carried out by Kersta, he argued that the process was a "reliable" one.

## "Voiceprint" Analysis and its Questionable Acceptance

As stated, it is a little difficult (even with its manual[8]) to describe the ways in which Sonagrams were used as a basis for attempts at speaker identification. For instance, one 'voiceprinter' tried to crossmatch the specific patterns of 10 common words[8] while another attempted to study the "bars, blades, blips and bands" displayed on the spectrogram apart from the specific patterns.[9]

Yet another specified that he required the exemplars of suspects to be exactly the same as the speech samples of the unknown speaker and attempted pattern-matching task on an unspecified number of features.[10] On the other hand, a fourth,[11] has unequivocally stated that it is difficult to define or quantify the pattern-matching process related to the technique implying that it still remains a mystery. As illustrated by these descriptions, analysis of "voiceprint method" can be a confounding one.

Since many of these events 'happened' in the United States during the 1960s, it is not surprising that "voiceprints" caught on. Of course, in the beginning, their use was not questioned. The relevant judicial fraternity was not familiar enough with the

method to challenge its use; nor were they aware that most members of the relevant scientific community were not in consonance with the said method and challenged its validity as an appropriate speaker identification approach. Thus, the "voiceprinters" became immuned to any sort of impeachment even by capable trial attorneys.

## Research by the Proponents

As expected, the "voiceprint" proponents claimed that their research supported the method's validity. Tosi et al.[12] carried out a key research where the "examiners" compared the sonograms of controlled utterances with the previously identified utterances. Results indicated that the correct identification rate varied from a little over 86% to nearly 96%.

From this, the authors stated that, "they were able to confirm Kersta's claim of an error rate of 1% false identifications." Unfortunately, they kept repeating that particular statement in the courts and, by doing so, erroneously suggested that "voiceprints" achieved an accuracy of 99% correct identifications in the forensic context. Further, the relationships they reported (i.e., 86% and 96%) were obtained from highly controlled laboratory procedures and not in the field. And, even other of their data -- contemporary and noncontemporary -- resulted in error rates of at least 18%.

The "voiceprinters" also referred to other "studies" they had conducted; while a few were limited in scope, others did not qualify to be serious research at all. For example, Smrkovski[13] testified in court that he examined the "voiceprints" of twins and found that their spectrograms did not match (not really a study). On the other hand, there were a couple of MA theses[10,14] used as a basis for the unreasonable claims they made as to the efficacy of voiceprints.

## Research by Neutral Investigators

In the years that followed, the "voiceprinters" were virtually unopposed (at least in the court) as they gave the impression that they had conducted all relevant research. Yet by that time, great strides were made in the area of speaker identification research. Stevens et al.[15] reported that the error rates associated with speaker identification based on spectrographic examinations by the subjects ranged from 21% to 47% whereas, subjects who carried out speaker identification based on listening scored somewhat better even when presented with a modestly difficult aural-perceptual task. Second, the Young and Campbell[16] research also reported far greater error rates than did either Kersta or Tosi. Hazen[17] utilized both closed and open sets as well as identifications from same and different contexts. His error rates also were substantially higher (12-57%) than were Kersta's or Tosi's. Many other investigators[18,19,20] tested yet other aspects of the "voiceprint procedure," but none achieved "hit rates" as claimed by the proponents.

## Addition of the "Listening" Procedure

In the early 1970s, owing to the growing resistance to the validity of the voiceprint method, the "voiceprinters" felt the need to add the listening procedure to their existing technique. This additional dimension required the examiner to first listen to the incriminating speech sample and compare it to the exemplar to identify if the two voices sounded similar or not. However, no appropriate -- or even structured -- procedures were described, no standards imposed, no examiner training specified, nor was any research on aural perceptual techniques (except Hall's[14]) reported.

## The "Voiceprint" Examiners

At this juncture, it would appear necessary to consider how the "voiceprinters" were trained. They claimed that their technique was good as their examiner-teachers had developed "exceptional skills" in identifying speakers. However, no test scores were provided to support this claim – that is, besides the few requisites listed for examiners by Black et al.[21] They indicated that the trainees must undergo a two-week course, training in audiology and speech sciences and complete at least two years of supervised apprenticeship dealing with field cases.

In addition, Truby[11] confounded this issue by adding that "being a speech scientist" does not qualify an individual in the area of "voiceprinting." He would disqualify anyone who had not "accumulated personal mileage pouring over sound spectrograms" and "who had not scrutinized thousands of voiceprints." Unfortunately, there was no description on whether the "examiner" is carrying out the procedure correctly and if his/her judgments are accurate. In conclusion, it may be indicated that the entire ("voiceprint") area can be found reviewed in Hollien.[22]

## A New Problem for the "Voiceprinters"

New standards for the proper development of speaker identification systems was established in the late 1980s. The most fundamental of them can be found in Hollien.[22] Then, in 1992, the Daubert evidentiary standards were published.[23] They specified exactly what was necessary before the results of a forensic procedure – of any type – could be admitted to trial. That is, to be considered valid, a theory or technique must have been tested scientifically and the resulting research subjected to peer review and publication. Even more important, it established the necessary platform for the development of any (forensic) analytical procedure. In doing so it validated the standards established by Hollien.[22] The next entity to address the standards issue was the U.S. National Academy of Science. A special committee, established by its Research Council, analyzed, and then published, a review of both the status and needs of the Forensic Sciences.[24] Its recommendations stressed that the validity of any forensic process or system must be based on "sound operational principles and procedures (as well as on serious research." It further stipulated that the standards

specified by Daubert must be followed. Finally, one only had to consult UK's Crown Prosecution Service (CPS) guides on experts and expert evidence[25] to better understand the above discussion. Indeed, the CPS Directorate has articulated them clearly and simply. They ask:

1. Whether the theory (or analysis) technique can be, or has been, tested;
2. Whether the theory (or analysis) technique has been subject to peer review and publication;
3. If the potential rate of error is known and if standards exist there; and
4. Whether the theory or technique used has been generally accepted by the relevant scientific community.

The criteria cited by these four sources are easily understood. Obviously, the individuals who employed the "voiceprints" procedure did not begin to meet the standards existing at that time, much less those specified by the sources cited above. Even more important, the four sets of cited standards must be followed when modern approaches to speaker identification are developed/researched. Fortunately, they tend to be met in most cases.

## The Future

Having concluded that the "voiceprint" technique is not a useful method of speaker identification, and that the aural-perceptual approaches cited are more of a stop-gap arrangement, the most reasonable solution to the problem rests on the development of human-controlled, computer-aided procedures.

Thus, it is fortunate that, the research on speaker identification continues unabated. Indeed, in the past 50 years, literally thousands of experiments, structural reviews and developmental studies have been conducted in the overall speaker recognition area. Many have been carried out by teams headed by the first author of this article. In turn, reviews of many can be found in his various publications.[22,26,27] Much of the new data was focused on two of the areas which have already been discussed. That is, on 1) basic SI research and 2) the enhancement of aural-perceptual SI approaches. As it turns out, there also is a third area -- speaker verification (SV) -- which, in many ways parallels these two. Basically, however, the goal of the SV systems is to identify a person who wants to be identified rather than avoid it. Nevertheless, research useful to individuals in the SI area -- and a great deal of it -- also is being conducted. Some overlaps it. One example of this third area (i.e., SV) is where a team of engineers[28] designed, built, and evaluated a series of automatic speaker verification systems. As a part of their evaluation procedures, they compared their output to the "hit rate" levels of human auditors (see the overlap?). For their earlier designs, the human auditors were more accurate. However, one of their newer systems has achieved a correct identification level of 80% -- a rate which was slightly higher than that of the human evaluators (78%). Of course, it must be remembered that the experiments using human listeners involve rather challenging (AP SI type) recognition procedures; that is, the speech stimuli judged are usually brief and embedded in foil samples. Hence, the recognition and response time are quite limited. A review of research (including data) and approaches to AP SI are available.[29] In any event, the research cited here provides a temporary "stop-gap" analysis procedure for use in Forensics. It also furnishes the SI field with useful information as well as additional evidence that human controlled "machine" processing appears to be the superior approach -- especially in the light of the advancements in technology which are now occurring. Another example here, is where engineers have actually developed working verification systems, ones that are actually in use as part of security systems.[30] Of course, SV involves substantially fewer variables than does AP SI but the cited systems are impressive nonetheless.

As stated, serious research on speaker identification originated during the same period as did the "voiceprint" controversy. A number of projects in that area emerged just after the middle of the 20th century; they, in turn, triggered actual SI systems. That is, a rather large number of related types of automatic and semi-automatic SI systems were proposed, designed, built and/or placed in operation. Most of them, however, have enjoyed but modest success. That is, as was the case with voiceprints, they often were put to use before they were properly developed and tested. It also has been observed that many of these systems were not based on the analysis of actual speech and voice and, as has been pointed out, they suffered from not doing so.[31,32] And, of course, any that did not compensate for a significant number of the external variables also were at a distinct disadvantage. One of the earlier semi-automatic systems[22,26,33] has shown considerable potential and continues to be upgraded (Fig. 2).

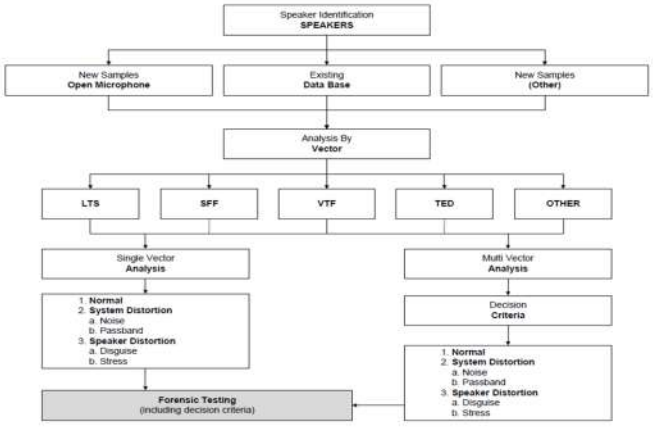


**Fig. 2:** Modification of the SAUSI developmental flow-chart. From Hollien [26]. This flow-chart provides a graphic view of the model described in the text. (It also parallels those later articulated by NRC and Daubert). This configuration is a working version of the original and includes the research steps which must be taken to develop a valid SI system. In this case, the vectors (i.e. clusters of the related parameters) are speech-based. The research protocol flows from the laboratory level, via several stages, to "real-life" situations.

It is based on speech/voice analysis and extensive experimental testing (refer to the cited work[27] for its research platform and its current structure). It also benefited from a number of "tests" in criminal investigations and trials (i.e., from practical, if not experimental, evidence).

Finally, there are many other SI systems available.[34,35] Indeed, it is unfortunate that these potentially effective systems cannot be reviewed in this report. However, it is only necessary to consult the bibliographies found in the listed references for appropriate pathways. In short, there are so many of these speaker recognition systems and approaches available, that there is little need to rely on the antiquated – and discredited – "voiceprint" approach.

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CASE REPORT

# Fatal laryngeal obstruction in a child by a balloon: A case report

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**Abstract**
Choking is a condition caused by inhalation of a foreign. Balloon aspirations are highly fatal and are the number one cause of non-food related choking deaths in children. We present a case of an 18 months old male child brought to the Department of Forensic Medicine for postmortem examination with an alleged history of death due to aspiration of the balloon. The deceased was playing with a balloon and then suddenly started having difficulty in breathing and bluish discoloration of the face. He was immediately rushed to a hospital where he was declared brought dead. At autopsy, a yellow colored balloon was found completely obstructing the airway. The application of continuous suction forces to the un-inflated or partially air-filled balloon is considered the most crucial factor in causing asphyxiation by a rubber balloon. Education of parents, child care providers and preschool teachers along with product labeling describing hazards must be made a routine to avoid such fatalities.

**Keywords**
Balloon; Choking; Foreign body; Aspiration

## Introduction

Choking is a condition caused by inhalation of a foreign object. Foreign body aspiration can be a life-threatening event especially in young children between 1 to 3 years of age because they have smaller diameters of airway lumen, moreover, the delay in the diagnosis and subsequent therapeutic intervention can further increase the risk of morbidity. This happens because younger children have natural tendency to put foreign objects in their mouths.[1]

Beside aspiration of food material, deaths also occur from common household and non-food objects such as metals and plastics, rocks, toys or parts of toys, coins, buttons and balloon. Death most often results from asphyxia due to compromise of major airways. Balloon aspirations are killers for children. They are the number one cause of non-food related choking deaths in children.[2,3]

The usual presentation is an acute onset of respiratory distress with or without history of choking. One must suspect foreign bodies in the respiratory tract in situations like refractory asthma, bronchiectasis, or hemoptysis and sudden death of an infant without any underlying cause. Meticulous autopsy should be performed in such cases with due emphasis on airway tracts. We are presenting a case of fatal choking in an 18 months old male child by a balloon.

## Case report

An 18 months old male child was brought to the Department of Forensic Medicine for postmortem examination with an alleged history of death due to aspiration of the balloon. On perusal of police inquest and history as narrated by the mother, the deceased was playing with a balloon and then suddenly started having difficulty in breathing and bluish discoloration of the face. He was immediately rushed to a hospital where he was declared brought dead and an autopsy was advised.

At autopsy, clothes of the deceased were found intact. The body was averagely built and nourished; eyes were partially open, mouth partially open with tongue inside the mouth. No oozing was seen from the mouth, nostrils or ears. Rigor mortis was well marked and generalized. Post mortem lividity appreciated and fixed on back & buttocks. Cyanosis of finger nails was present. There was no evidence of any surface injuries on the body (Fig. 1A).

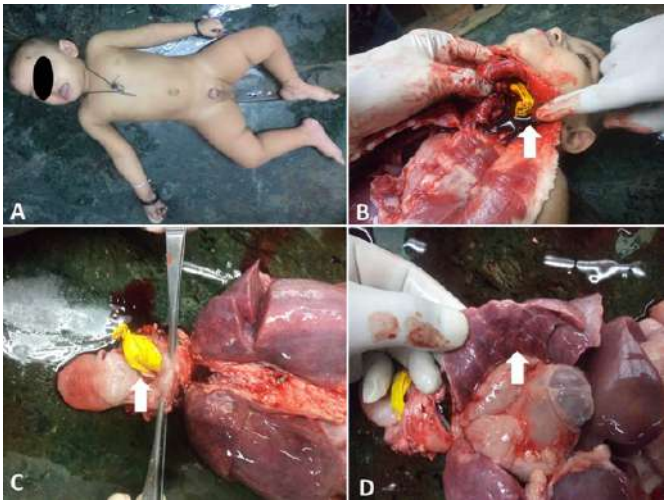


**Fig. 1: A**-Lifeless baby lying in supine position with no evidence of surface injuries; **B**-Yellow balloon is seen in the airway; **C**-Balloon obstructing the larynx at the level of vocal cords; **D**-Presence of petechial hemorrhages on the undersurface of right lung

On internal examination, a yellow colored balloon was noticed during en-bloc removal of viscera in the larynx at the level of

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vocal cords, obstructing the lumen completely (Fig. 1B & 1C). Laryngeal mucosa was lined with mucus and hemorrhagic at places. Lungs were intact, congested and edematous with petechial hemorrhages present on the surface of the middle and lower lobe of the right lung (Fig. 1D). The stomach contained about 50cc clotted milk. All other visceral organs were intact and congested. Opinion as to the cause of death was given as "Asphyxia following choking due to aspiration of balloon."

## Discussion

Ninety percent of deaths from foreign body aspiration occur in the patients who are younger than 5 years, and two-thirds of these deaths occur in infants. Aspiration of food particles is more frequently encountered in the first year of age, whereas foreign bodies other than food material are more common in older children.[2]

Pathophysiological considerations for aspirated foreign bodies include the anatomy of the lodgment site, the physical properties of the foreign body, and the local tissue reaction to the foreign body. High-risk objects create more morbidity than the low-risk objects. High-risk objects include any small hard pieces of food, especially nuts or nut fragments, seeds, raw carrots, raw apples, raw pears, unpopped popcorn kernels, dried peas or beans (which expand rapidly as they absorb moisture and therefore require urgent bronchoscopic removal), or any small pieces of toys, plastic, metal, pebbles, stones, or beads. Low-risk objects include processed dried cereal, wet noodles, chips, pretzels without nuts, soft or pureed foods, and cheese.[4]

Mechanism of asphyxia by balloon has been described in literature.[5] The application of continuous suction forces to un-inflated or partially air-filled balloon is considered the most crucial factor in causing asphyxiation by a rubber balloon. An un-inflated balloon is usually placed outside the mouth cavity where the child sucks the balloon into the mouth, either during a repeated trial of inverting the balloon inside-out or during the application of a direct suction to their bulb. A partially air-filled balloon is usually placed inside the mouth cavity then it is pushed further inside by movements like sucking or chewing. Other important factors are a sudden slippage of the mouthpiece from the fingers or teeth of the child, as well as the panic of the suffocation. The process of suffocation is also facilitated by the counterforce, which results from a sudden pressure of the mouth cavity over the bulb of the balloon, and the consistency of the balloons as pliable objects.

## Recommendations

- Strategies to reduce exposure to potentially hazardous foreign bodies include education of parents, child care providers and preschool teachers; caregiver vigilance; and clear product labeling describing hazards.
- Pediatric health care providers should emphasize that children, especially toddlers and preschoolers, be supervised during eating, and caregivers should discourage playing while eating.
- Caregivers also should be instructed to keep dangerous toys, foods and household items out of children's reach.
- Basic CPR, Heimlich maneuver and choking resuscitation training must be made widely available which may reduce mortality when choking occurs.

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CASE REPORT

# A case of cocaine trafficking via body packer as reported by chemical examiner laboratory, Punjab, India

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**Abstract**
Drug trafficking is a global illicit trade. The international drug trade uses various methods to smuggle narcotics. These methods include hiding the narcotics in vehicles or carried items, attaching them to one's body or use of the body as a container. A viscera case was received by Chemical Examiner Laboratory (CEL) in July, 2015 with history of suspected drug overdose along with two capsules (one intact and one ruptured). This was a case of body packer which was clarified from the copy of postmortem report (PMR) sent by autopsy surgeon along with various exhibits. We are writing this case because this is the only reported body packer syndrome in which viscera was analyzed by CEL.

**Keywords**
Chemical Examiner Laboratory; Viscera; Cocaine; Body packer

## Introduction

Drug smuggling by internal bodily concealment, called body packing is a widespread method of transporting narcotics.[1] Body packer also known as swallower, mule and the internal carrier describes an individual who conceals illicit drugs contained in small packets or capsules within the body.[2] The first case of body packing was reported in Canada in 1973, when a young man presented with bowel obstruction after swallowing a single condom filled with hashish.[3] Body packers usually smuggle cocaine, less commonly heroin and rarely amphetamine, ecstasy, marijuana and hashish.[4] There have been reports of ingestion of more than one type of narcotic.[5] Body packer syndrome is the term used to describe individuals who present with intestinal obstruction from impacted packets or specific drug toxicity due to rupture of one or more drug-filled packet.[6] Packet failure may occur in country of origin, during flight or at their destination and may present to health care providers as body packer syndrome.[7] Although the packets or containers are not usually condoms, as they were in the early days of body packing, the industrially produced containers used today can still rupture, causing a life-threatening drug overdose.[5] Even if the packets do not rupture, drugs may passively diffuse from the stomach into surrounding organs and appear in the circulation and urine.[8] Drugs such as loperamide or diphenoxylate hydrochloride with atropine may be taken by body packers to reduce gut motility and prevent the passage of the packages on a long-distance flight, before the end of journey.[8] After reaching the destination body packers usually defecate the containers using laxative.[8]

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## Case Report

A viscera case (stomach, small intestine, large intestine in one jar, Liver, spleen, kidney in one jar, blood in one jar and preservative in one jar) was received by CEL in July, 2015 along with 2 capsules (one intact and one ruptured in one jar). A copy of PMR was also sent by autopsy surgeon with following observations:

Stomach was found to be enlarged and irregular in shape by autopsy surgeon. Autopsy surgeon recovered 22 (20 intact and 2 ruptured) whitish, elongated, cylindrical capsules from stomach with white plastic material attached with the capsules and 28 similar capsules from the intestines, but without white plastic material (12 from small intestine at various levels, 16 from large intestine and rectum, two of them came out of the anal opening). According to autopsy surgeon, capsule with the white plastic material attached weighted 16 g and without it weighted 15 g. According to PMR, total weight of 50 capsules was 727 g and length of each capsule was 4.8 x 1.9 cm.

**Fig. 1:** White colored hardened mass

After chemical analysis, cocaine was found to be positive in all the biological exhibits viz stomach, small intestine, large

intestine, liver, spleen, kidney and blood. No cocaine was found to be positive in sample of preservative. Cocaine hydrochloride was found to be positive in both capsules, intact and ruptured. White colored hardened mass (Fig. 1) was recovered from intact and ruptured capsules. The percentage purity of the cocaine hydrochloride found positive in capsules was 50.97%.

## Discussion

Cocaine has a short half-life of 0.7-1.5 hours and is extensively metabolized by cholinesterase enzymes (primarily in the liver and plasma) with only about 1% excreted unchanged in the urine.[9] The phenomenon of drug smuggling by body packing has been a common practice from many years.[5] Drug trafficking is much more prevalent in India due to its geographical location, but only few body packer syndromes are reported in the literature. Almost all international studies reported cocaine as the most commonly smuggled drug by body concealment,[3] may be due to its higher financial worth. The total value of the cocaine packages may range from US $1,000 to over US $1,000,000.[10] Cocaine is highly toxic, the acute lethal oral dose is 1.2 g, but death has been described after the ingestion of only 20 mg.[11] Body packers usually carry around 1.0 kg of concealed drugs distributed over 50-100 packets but cases have been described where individuals carried more than 200 packets.[4]

Detection of body packing is an important task for the emergency physicians because it requires immediate medico-legal attention because packages can rupture, releasing lethal dose of drug into the body.[12] Body packers are usually with financial difficulties, low level of educational attainment and are unaware of health threats of ingesting packets.[13] Therefore, prevention programmes can be best implemented by educating susceptible groups such as people from low socioeconomic status.

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CASE REPORT

# Alert today-alive tomorrow: A report of unusual traffic deaths involving bamboo

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**Abstract**
Road traffic injuries are currently estimated to be the ninth leading cause of death across all age groups globally, and are predicted to become the seventh leading cause of death by 2030. This rise is driven by the escalating death toll on roads in low and middle income countries, particularly in emerging economies where urbanization and motorization accompany rapid economic growth. Two cases of unusual traffic deaths involving bamboo are reported in this paper. On separate instances, the victims were coming on two wheelers and collided with another vehicle carrying bamboo poles. In both instances, the victims died from injuries inflicted by the bamboo poles. "Being alert today will keep one alive tomorrow" is the message suggested by this paper.

**Keywords**
Road traffic accident; Fatal injury; Bamboo; Laceration of heart; Maxillary artery laceration

## Introduction

Road traffic injuries are currently estimated to be the ninth leading cause of death across all age groups globally, and are predicted to become the seventh leading cause of death by 2030. This rise is driven by the escalating death toll on roads in low- and middle-income countries, particularly in emerging economies where urbanization and motorization accompany rapid economic growth.

India stands out miserably in the latest World Health Organisation's "Global Road Safety Report-2015" with an estimated 207,551 deaths on roads.[1] In recent times, exponential increase in the number of vehicles, high speed technology, and with other contributing factors like rash and negligent driving, violation of traffic rules, inadequate road traffic planning and traffic signals, bad condition of road likes potholes, no proper indication of humps, blind cures and vehicle, congestion of roads and road side dhabas and bars, non-use of helmet, no proper pedestrian pathway, intoxicating influence of alcohols and drugs, late night driving due to job requirement, distracting hoarding / advertisement, use of mobile phones while driving, etc. lead to road traffic accidents, etc.[2]

Two cases of unusual traffic deaths involving bamboo are reported in this paper. On separate instances, the victims were coming on two wheelers and collided with another vehicle carrying bamboo poles. In both instances, the victims died from injuries inflicted by the bamboo poles.

## Case Report

**Case 1:** The deceased who was riding an Enfield motorcycle collided with one bullock cart loaded with bamboo on the road and succumbed to his injuries at the spot.

The autopsy was done at the tertiary hospital mortuary. Externally, the injuries were multiple; and included abraded contusions over an area of 23cmX16cm on the front of the upper part of the chest and left shoulder with a penetrating wound 5cmX4cmXcavity deep lacerating the apex of the left lung lacerated wound 17cmX10cmXmuscle on the front of left elbow & forearm and an abraded contusion, 11cmX5cm on the lower part of left side of chest with a penetrating wound 4cmX1.2cmXcavity deep, lacerating the left ventricle of the heart (Fig.1 and 2).


**Fig. 1 :** External penetrating injuries caused by the bamboo.


**Fig. 2 :** Laceration of the heart caused by penetrating injury with the bamboo.

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Internally, there was fracture of left 3rd-5th ribs anterolaterally. About 1.5 litres of blood were present on the left side of the chest cavity. The left ventricle and the upper lobe of the left lung were lacerated. The death was attributed to laceration of the heart and lung produced by penetrating injury to the chest which was accidental in nature.

**Case 2:** A Honda Activa rider was struck by a bamboo pole when the two persons carrying the bamboo pole suddenly crossed the road at a busy highway. He succumbed to his injuries at the casualty a tertiary care hospital at of the same day.

Autopsy was conducted in the same mortuary as above. Externally, the injuries included (i) a lacerated wound on the occipital region horizontally placed across midline, 147cm above heel, 4cmX0.2cmXscalp with red irregular margins. (ii) lacerated wound (with 8 stitches)on the left cheek, inverted U shaped, 6cm from midline, 140cm above heel, 16cmX0.4cmXbone with red irregular margins and (iii) a lacerated wound on the left earlobe, 154 cm above heel, 1cmX0.2cmXsubcutaneous tissue with red irregular margins.

Internally, the scalp was lacerated and contused over the occipital region with fracture of the left angle of mandible and laceration of facial muscles on the left side with laceration of the left maxillary artery and its branches (Fig. 3 and 4)

**Fig. 3 :** Stitched wound on the face at the site of laceration caused by the bamboo.

**Fig. 4 :** Tear of the maxillary artery caused by the bamboo.

Chest cavity was intact. Stomach contains about 500 gm of dark chocolate coloured fluid mixed with semi digested food particles. The death was attributed to shock and haemorrhage resulting from laceration of the maxillary artery produced by blunt force injury to the head which was accidental in nature. The time since death was 2-4 hours. Injuries were antemortem in nature and fresh at the time of death.

## Discussion

Mandal and Sanusi,[2] found that Penetrating Cardiac Injury (PCI) occurred in 6.4% of the penetrating chest injuries, one of the most frequently injured body segments. Historically, heart injuries had fatal outcomes and were considered untreatable,[3] even today, about 90% of the patients die before reaching the hospital.[4,5] Different case series have reported survival rates ranging from 3 to 84%.[5] Some authors have found associations between mortality and patient's hemodynamic status upon admission, kind of weapon used, wound characteristics, surgical findings, and complexity of the repair.[6]

Trauma characteristics may change according to social context, for example in blunt chest trauma, which is more frequent in developed countries, 30% of cardiac compromise has been reported. Survival rate for patients admitted to emergency departments in a shock state after PCI is about 35%, while for blunt chest trauma this rate is about 2%.[3] In the USA, the ratio between PCIs from gunshots (PCI-GSW) and from stabbing (PCI-SW) is 2:1 but in developing countries the latter is more frequent.[1,5] These differences may influence the results of reported series. But PCI resulting from a freak vehicular accident where victim was hurt by a bamboo carried on the colliding vehicle is rare and can cause a fatal injury on the spot for which the case is being reported.

Regarding the second case, the internal maxillary artery (IMA) is the last terminal branch of the carotid artery. Because of its deep lie, hemorrhage cannot be easily managed by digital pressure.[7] Maxillary artery (MA) is the largest terminal branch of the external carotid artery. Because of its deep lie, hemorrhage can be difficult to manage.[8,9] Condylar fractures of the mandible are one of the principle causes of MA lesions. A possible mechanism of MA rupture in such ract is the direct lesion caused by fractured bone.[9,10] In the present case, the direct trauma is the penetrating injury caused by the bamboo pole which is quite unusual. Basing on the entity and the dynamic of the trauma, a lesion of MA can cause a classic hemorrhage, which is considered the most dangerous event. This in fact was the cause of death in the present case. A freak accident resulting in a serious cause of death for which the case is being reported.

In both instances the accidents were unusual ones but the results were fatal. In today's fast life, where the road is almost like a battlefield, traffic fatalities are a run of the mill affair. Therefore, additional problems caused by gross neglect of traffic sense should be avoided. Strict traffic rules should be enforced and safety precautions imposed on all vehicles carrying various types of goods. Besides, emergency management in hospitals should be prompt and competent.

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CASE REPORT

# Fatal atypical missile injuries

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**Abstract**
The missile injuries predominately occur by explosive devices and firearms, but sometimes these injuries occur by high velocity objects such as stones and metallic articles, which may cause fatal injuries resulting in death. Boththe cases presented here are rare and uniquewith reference to the dramatic, sudden and unforeseen incidences, manner of causation of injury and limited availability in literature.In this article we have presented two cases, in which death has occurred due to penetration of non-ballistic missile objects propelled by wheels of high speed running train. Accidental injuries due to missile objects are rare, but severe nature of such injuries may lead to death. In both the cases high speed objects propelled by train had caused severe damage to internal organs causing death. Eventhough the incidences are very much uncertain and unforeseen to take preventive measures but awareness should be made among the peoples. Saving a 'single life' by such a step will achieve the purpose of this article, because every single life is important.

**Keywords**
Penetrating injury, Non-ballistic missile, Propelled stone, Propelled iron rod.

## Introduction

The word missile is derived from the latin verb “mittere” means mitte= to send and tilis= to throw.” The missile can also be defined as, an object which is forcibly propelled at a target, either by hand or from a mechanical weapon[1] or it is a weapon thrown, shot or propelled at target such as a stone, bullet, arrow or rocket. As far as this article is concerned the missile objects are only limited to the propelled non-firearm and non-explosive articles and injuries caused by them.

Penetrating trauma is an injury that occurs when an object enters the body by creating an open wound. While penetrating trauma implies that the object does not pass through, perforating trauma is associated with an entrance wound and an often larger exit wound. Penetrating trauma can be serious because it can damage internal organs and presents a risk of shock and infection. The severity of the injury varies widely depending on the velocity of object, body parts involved, the characteristics of the penetrating object and the amount of energy transmitted to the tissues,[2]

Wound is produced by a mechanical force of moving weapon or object and counterforce provided by inertia of body. Due to this, the energy is transferred to tissues of body from moving object which causes change in state of rest or motion. The human body contains many complex tissues which greatly vary in their physical properties such as state of solidity, fluidity, density and elasticity. This is the most important factor in causation of mechanical injury. Thus the mechanical force causes displacement, deformation or traction strains, shearing strain, causing rupture of tissues.[3] The second most important factor in this mechanism of causation of injury is kinetic energy of the moving object. This is given by equation; $KE = 1/2\ MV^2$ Where, M= mass of body, V= velocity of moving object.

Objects with definite velocity and definite weight have a definite amount of energy. This indicates that velocity has far more influence on energy as compared to mass of object. The space left by tissue that is destroyed by the penetrating object as it passes through body forms a cavity; this is called permanent cavitation. In addition to causing damage to the tissues, a medium and high-velocity projectile causes a secondary cavitation injury as the object enters the body. It creates a pressure which forces the tissue out of its way, creating a "temporary cavity" that can be much larger than the object itself.[4,5]

## Case Report

**Case 1:** This incident happened during the celebration of marriage ritual, where the friends and family members of both bride and groom were dancing just before the marriage ceremony. When the function was going on near the railway track, a stone called as 'gitti' (a type of hard, flat, irregular and somewhat sharp stone, used to prepare the railway track), was propelled by the wheels of high speed train. The propelled stone suddenly pierced into the body of deceased from back on left side. He immediately fell on the ground and blood was flowing from the wound copiously. The incidence was witnessed by many people, family members, and friends. He was rushed to Government medical college and hospital, but unfortunately he was declared as brought dead at casualty. So being a medico-legal case, the body was forwarded to Department of forensic medicine for post-mortem examination.

*External examination:* The body was examined at mortuary of

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Government Medical College and Hospital. The cloths were stained by blood and mud particles at places, torn at left posterior aspect of body over an area of size about 15 cm x 5 cm, with dried blood stains at places. On removal of cloths, the body was average built, extremely pale. Penetrating lacerated wound was present on posterior aspect of left side of body 2 cm below the angle of scapula and 7cm lateral to midline (Fig. 1A).

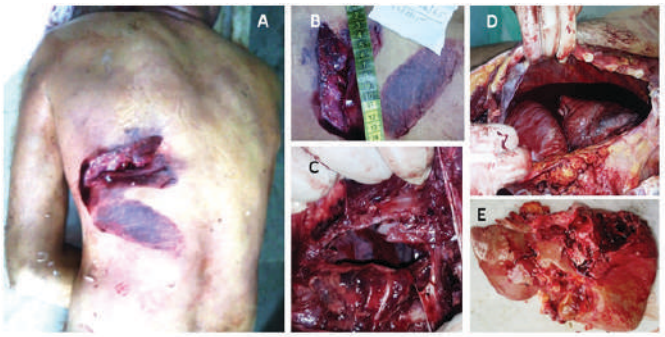


**Fig.1 A:** Lacerated wound produced due to penetrating injury by propelled stone over left side posterior aspect of body, **B**: Close view of the lacerated wound, **C**: Fractured ribs and open thoracic cavity, **D**: Blood in pleural cavity due to laceration of lungs, E: Lacerated wound at posterior surface of right lobe of liver.

The size of injury was 13 cm x 4.5 cm x cavity deep, obliquely placed with irregular, ragged, uneven margins, with blunt acute ends. Lower margin of wound was somewhat undermined, with contused borders all around the lacerated wound. Contusion of size 15 cm x 6 cm was present immediately below the lacerated wound (Fig. 1B).

*Internal examination:* The propelling object entered the body through the lacerated wound and fractured 7$^{th}$, 8$^{th}$ and 9$^{th}$ ribs 6 cm lateral to their attachment with spine (Fig. 1C). The left pleural cavity contained about 300 ml of blood and blood clots (Fig. 1D), and peritoneal cavity contained about 550 cc of blood and blood clots. The object then pierced into intercostal muscles and lacerated postero-lateral aspect of lower lobe of left lung. The laceration over lung was of size 4cm x 3cm x parenchymal deep. It further extended to rupture the diaphragm. Then the track of wound further extended downwards and medially causing the laceration of spleen of size 7cm x 2cm x parenchymal deep at supero-lateral surface, then further it extended to lacerate the posterior surface of liver of size 7cm x 2cm x parenchymal deep (Fig. 1E). Fracture of spine was present at the level of T10 to T12 level with infiltration of blood in surrounding region. The cause of death was given in this case as shock and hemorrhage due to injury to vital organs.

**Case 2:** In the second case, the railway workers were working on railway track for maintenance work, when there was an announcement regarding the arrival of express train. All of them stopped working and stood about 10 meters away from the track. The deceased person was talking to his co-workers with his back facing towards the railway track. Suddenly, an iron rod, lying on railway track stuck into the wheels of high speed train and was propelled by it with great speed. The object suddenly penetrated through the victim's occipital region of head. The iron rod pierced the scalp and fractured the occipital bone, causing laceration of meninges and bilateral occipital brain matter. The incidence was witnessed by all the co-workers standing over there. The patient was shifted to casualty Government Medical College by co-workers, but he was declared brought dead by casualty medical officer. For further medicolegal procedure deceased was shifted to autopsy room.

*External examination:* The diseased was average built, of age about 40 years; cloths were stained with blood and mud particles. The iron rod was present in situ in the wound at occipital region (Fig. 2A).

On removal of rod, blood was oozing out from the wound, and the iron rod had pierced about 8 cm inside the cranial cavity. The length of the iron rod was 31 cm and diameter was 2.5 cm. The deceased had only one injury, i.e. the penetrating lacerated wound present over the occipital region of scalp of size 5cm x 4 cm x cavity deep, irregular, ragged, uneven margins and circular shaped with blood stains present surrounding the wound (Fig. 2B).


**Fig. 2 A:** Iron rod in situ propelled from wheels of train and penetrated into cranial cavity, **B**: Wound on removal of iron rod, **C**: Skull and its contents after removal of scalp

*Internal examination:* On opening the cranial cavity, all the layers of scalp were penetrated with under scalp hematoma of size 6 cm x5 cm around the wound over occipital region, dark red in colour. The skull bone of size 5x5 cm was missing from the site at occipital bone creating a opening of same size in the skull (Fig. 2C). On opening the cranial cavity meninges were torn; subdural and subarachnoid hemorrhages was present all over the brain matter at places, and brain matter was lacerated along the track of penetration injury upto 8 cm.

## Discussion

In case of high velocity missile projectiles, tissue cavitation and shock waves are the main causes of complex injuries and poor prognosis. Whereas, in case of non- missile projectiles with impact velocity <100 m/second, direct disruption and laceration

of tissues are the main causes of the localized primary injury and better prognosis[6]. These non-missile projectiles include different metallic, wooden, stony, glassy and other industrial or environmental objects.[6-8] The decisive factor will be the energy expended within tissues after penetration.[5]

The parenchymatous organs such as liver, spleen, muscles are particularly prone to damages by high velocity missile objects,

$$\text{Energy expended} = \text{Mass} \times \frac{\text{strike velocity}^2 - \text{remaining velocity}^2}{2}$$

the extent of which is inversely proportionate to the elastic fiber content of tissue. Tissue damage due to high velocity missile objects injury results not only from the direct effect of missile penetration, but also from the indirect effect of shock waves on distant tissues and organ systems and from the cavitation effect.[7] The tissues damaged due to penetration will soon move back into place, eliminating the cavity, but the cavitation frequently does considerable damage first. Temporary cavitation can be especially damaging when it affects delicate tissues such as the brain, as occurs in penetrating head trauma.[2]

Penetrating chest trauma can damage vital organs such as the heart and lungs and can interfere with breathing and circulation. Lung injuries that can be caused by penetrating trauma include pulmonary laceration, contusion, hemothorax, pneumothorax, hemopneumothorax. Penetrating abdominal trauma can be life-threatening because abdominal organs can bleed profusely, and the space can hold a large volume of blood,similar to this case. Injuries to the liver are common because of the size and location of the organ, and present a serious risk for shock because the liver tissue is delicate and has a large blood supply and capacity.[2,9,10] The similar pattern of injuries has occurred in this case.

The outer table of skull is twice in thickness as compared to inner table.[9] In adults, thickness of skull bones is 6 to 10 mm in frontal and parietal, 4 mm in temporal, and 15mm in occipital, so occipital is the thickest bone. Under experimental conditions, force of 400 to 600 pounds per square inch is needed to fracture a cadaver skull covered by intact scalp and hairs.[3] In present case the heavy object was propelled with such a great speed that it has not only pierced the scalp but also fractured thickest part of skull i.e. occipital bone over occipital protuberance, also ruptured the meninges and lacerated the brain and entered into brain upto 8 cms.

## Conclusions

The reported cases thus, highlight on the rare accidental injuries due to missile objects that may lead to loss of lives. These incidences are very much uncertain and unforeseen for preventive measures to be taken, but its awareness certainly would help autopsy surgeons in correct interpretation in similar unwitnessed cases, where doubts of homicides are made.

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CASE REPORT

# Sudden death due to acute hemorrhagic necrotizing pancreatitis

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**Abstract**

It is a great challenge for a forensic pathologist to solve a case of sudden and unexpected death. World Health Organization (WHO) defines sudden death as "death occurring less than 24 hours from onset of symptoms, not otherwise explained". It is also defined as death known not to be violent or instantaneous for which no cause can be discovered and death without a sign of disease. Sudden death involving the pancreas remains a rare and unusual condition. The reason behind the sudden unexpected death due to pancreatitis is the rapid progress of the condition. A most common symptom in acute pancreatitis is abdomen pain and vomiting. Alcohol consumption affects the pancreas by direct injury to the acinar cells, ductal obstruction and also hampers the intracellular transport finally landing up in acute pancreatitis. We report a case of acute hemorrhagic necrotizing pancreatitis in a middle-aged male due to chronic alcoholism, substantiated by the histopathology findings, and positive blood alcohol levels. A thorough evaluation of history along with a meticulous autopsy is helpful in finding the etiology of sudden death, especially in the middle-aged adult population. This case highlights the forensic expert's anticipation with reference to sudden death due to inflammatory pathology.

**Keywords**

Sudden death; Hemorrhagic necrotizing pancreatitis; Alcohol

## Introduction

It is a great challenge for a forensic pathologist to solve a case of sudden and unexpected death. Sudden death is defined by various authors. World Health Organization (WHO) defines sudden death as "death occurring less than 24 hours from onset of symptoms, not otherwise explained". It is also defined as death known not to be violent or instantaneous for which no cause can be discovered and death without a sign of disease.[1] In such instances, the availability of clinical workup and other details regarding the case are seldom present. So autopsy is the only way by which cause of death could be ascertained.[2-5]

The most common cause of sudden death, in the order of descending sequence, is cardiovascular system (45%), respiratory system (25%), nervous system (20%) and others (10%).[6] Tong et al concluded that sudden death in acute hemorrhagic pancreatitis, is common at night during sleep and healthy active males were the common victims.[7] The reported incidence of acute pancreatitis diagnosed first at clinicopathologic autopsy ranges between 30% and 42%.[8-11] The overall mortality rate of acute edematous pancreatitis is less than 1%, but the acute severe hemorrhagic pancreatitis has a mortality rate ranging from 13.5%–24% suggesting the severe nature of hemorrhagic form.[12-14]

Sudden death involving the pancreas remains a rare and unusual condition. The reason behind the sudden unexpected death due to pancreatitis is the rapid progress of the condition.[15] We report a case of acute hemorrhagic necrotizing pancreatitis in a middle-aged male due to chronic alcoholism, substantiated by the histopathology findings, and positive blood alcohol levels.

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## Case Report

A 36-year-old male complained about an unbearable epigastric pain in the evening at 4.30 pm. He was referred to a private hospital. He was treated with intravenous pantoprazole injection to him. He came back to his house. Next day about 07.00 am he had severe abdomen pain and it was radiating to back. He also had two episodes of hematemesis. He was referred to this tertiary health care center and declared dead on arrival to the emergency department at 10.22 am. Police conducted inquest and referred the body for autopsy. On inquiry to his friends, it was revealed that he had a heavy bout of alcohol booze since afternoon on the previous day.

On autopsy, external examination showed he was moderately built, the length of the body 173 cm, weighing 90 kg. The face was congested, and bluish discolorations of nail beds were appreciated. The dark brown fluid was oozing out from his mouth and nostrils. No obvious external injuries were present. Post mortem lividity was present over the back and fixed.

Internally all organs were congested. The brain was congested. Lungs were congested and edematous. Left anterior descending artery showed 60% eccentric atherosclerotic blockage (Fig. 1A) and the left circumflex artery showed 20 % atherosclerotic blockage. Left ventricle thickness was 2.3 cm (Fig. 1B). The lower end of the esophagus showed congested mucosa and varices. Peritoneal cavity contained 750 ml of blood-stained fluid. The stomach contained 50 ml of coffee brown colored fluid. It showed hemorrhages on the posterior surface and on both curvatures (Fig. 2A). The liver weighed 2.5 kg, yellowish colored and enlarged suggestive of fatty liver. The gall bladder was dilated and contained brown colored viscid bile without any

gall stones. Weight of pancreas and spleen were 110 gm and 250 gm respectively. Pancreas showed hemorrhages on cut section (Fig. 3A). The retroperitoneal hematoma was present near soft tissues of the upper pole of the kidney, left mesentery, and mesocolon. Left and right kidneys were 144 gm and 150 gm in weight respectively.

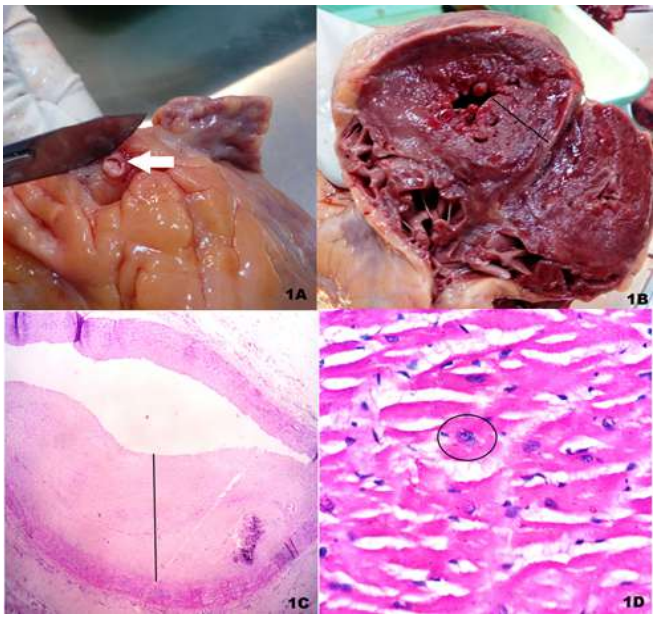


**Fig. 1: A & C:** Shows the gross and histopathology image of atherosclerotic blockage of Left anterior descending artery; **B:** Shows the gross hypertrophy of left ventricle. **D:** Shows histopathology image of hypertrophic left ventricle and multiple box car nuclei.

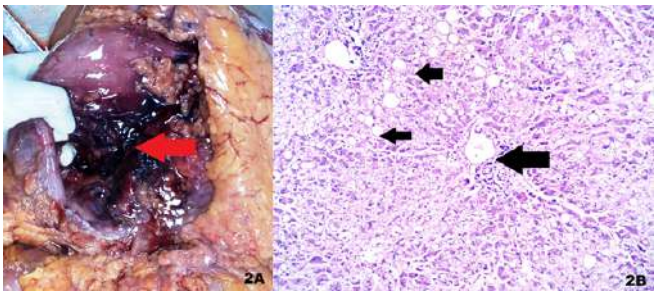


**Fig. 2A:** Hemorrhages on posterior surface and on both curvatures of stomach; **2B:** Micro as well as macro vesicular steatosis with evidence of steatohepatitis.

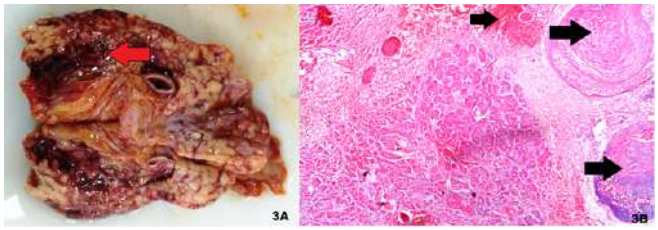


**Fig. 3A:** Cut section image of hemorrhages in pancreas; **3B:** Extensive areas of hemorrhage and necrosis in pancreas.

On histopathology, the liver showed extensive micro as well as macrovesicular steatosis with evidence of steatohepatitis (Fig. 2B). Sections from pancreas showed extensive areas of hemorrhage and necrosis suggestive of hemorrhagic necrotizing pancreatitis (Fig. 3B). Sections from esophagus are unremarkable. Sections from left ventricle show hypertrophic cardiomyopathy (Fig. 1D), however no evidence of myocardial infarction or myocarditis. Sections from right ventricle are unremarkable. Sections from aorta show the small focus of atherosclerosis. Sections from the left anterior descending artery show intimal fibrosis with calcification occluding 50 to 70% of the lumen (Fig. 1C). Sections from the left circumflex artery showed mild intimal fibrosis.

Alcohol (96 mg%) was detected in the blood. Viscera were negative for alcohol. Based on the complete autopsy examination, the cause of death was opined as acute hemorrhagic necrotizing pancreatitis due to chronic alcoholism with evidence of alcohol in the blood.

## Discussion

Pancreas, predominantly an exocrine (80-85%), but also an endocrine (1-2%) is the regulator of many physiological processes in the human system, by secreting various enzymes. It is a retroperitoneal organ which lies across the posterior abdominal wall placed transversely. It is divided into head, neck, body, and tail anatomically with its tail lying anterior to left kidney. The ductal, vascular, nervous supply to the organ helps in the problem less function of the pancreas. Toxins like alcohol cause damage to the vascular and ductal system may result in pancreatitis. It is a reversible condition which occurs due to injury to parenchyma by various etiologies. The common etiologies are alcohol and biliary tract disorders in western countries.[16]

Hyperlipidemia, hypocalcemia, drugs like didanosine, valproic acid, opioids, azathioprine, and blunt trauma to the abdomen can cause pancreatitis. A most common symptom in acute pancreatitis is abdomen pain and vomiting. Kanchan et al reported a similar case of acute hemorrhagic pancreatitis at autopsy in a young doctor, due to a misdiagnosis of radiating pain as gastritis. He had on and off abdomen pain for past one week. He had an episode of vomiting the day before his death. He was found dead at his bed during the night at his workplace.[17] The present case had epigastric pain, which was on and off in nature. He also had an episode of vomiting before death. Sahnoun et al reported lethal pancreatitis at autopsy, where the deceased presented with chest pain followed by generalized tonic-clonic convulsions occurring at night 30 minutes before the consultation.[18] In the present case, signs and symptoms started in the evening and aggravated in the night time.

Chronic alcoholism affects the pancreas by direct injury to the acinar cells and ductal obstruction. It also damages the intracellular transport causing acute pancreatitis.[19] Tsokos et al concluded that alcohol is a most probable etiology of pancreatitis in nineteen cases out of twenty seven cases.[20] Shetty et al in their case series concluded that the mean age of their series is 35 years, with male to female ratio as 6:1. The major etiology was due to chronic alcoholism (80%) and others (10-20%) are idiopathic. Shetty et al also highlighted the hemorrhage associated with necrosis in all the cases in their

series.[21] In our case, the deceased was a 36-year-old male with a history of chronic alcoholism.

A study involving forty four cases of severe bleeding following acute pancreatitis had mortality rate of 34.1%. The portal vein is the common source of bleeding associated with 50% mortality, followed by splenic artery, spleen, and unspecified peripancreatic vessels. Massive hemorrhage is associated with severe necrosis, having mortality up to 37.9%.[22] Acute hemorrhagic necrotizing pancreatitis is the cause of death of the present case which can cause sudden death.

In the routine autopsy, the frequent diagnostic difficulty faced by the autopsy surgeon is the autolysis of the pancreatic specimens due to its enormous enzymatic activity. This creates hindrance to the pathologists in appreciating the architecture of the pancreas. The common pathologies found in the pancreas are calcium deposits, inflammatory infiltrates, necrosis and hemorrhages. Loss of architecture due to post mortem autolysis leads to the loss of significant findings. Hence the better time interval for studying pancreas histologically is till 8 hours after death. Sometime samples may be taken up to 12 hours after death.[23] In the present case pancreas for histopathology was taken within 6 hours after death.

The chronic consumption of alcohol causes acinar cell disruption and loss of protective factors in the pancreas and activates trypsinogen extensively. This trypsinogen activation along with the other proteolytic enzyme activation damages the peripancreatic and pancreatic tissues. These enzymes damage the cell membrane and cause proteolysis, interstitial hemorrhages, vascular damage, coagulative necrosis. This finally causes hemorrhagic necrotizing pancreatitis.[24] This could be a possible mechanism for hemorrhagic necrotizing pancreatitis in the present case. Hence based on a detailed dissection, histopathology, and viscera analysis, we concluded acute hemorrhagic necrotizing pancreatitis as the cause of sudden death.

## Conclusion

This case highlights the role forensic expert in identifying the cause of sudden death. In such a scenario, meticulous autopsy and ancillary studies are needed to find out the proper cause of death. We are also highlighting the clinical presentation and underlying pathology of acute hemorrhagic necrotizing pancreatitis. So, that sudden death can be prevented by a proper and timely evaluation of similar cases.

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**LETTER TO THE EDITOR**

# Forensic entomology: Applications in investigations

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*Dear Editor,*

*Who saw him die? I, said the fly,*
*with my little eye, I saw him die.*

Insects are arguably the first witnesses to any crime on the account of them being the largest class amongst the Animal domain. Use of insects for investigating crimes began as early as 12th century AD, in China, where detectives kept flies in boxes and used them as an investigative aid. According to the legend, the flies once let loose by the investigators, would seek out traces of evidences invisible to the naked eye. In 1235, Sung Tzu, a judicial intendant in China, authored the first book showcasing use of flies in criminal investigation. These episodes marked the beginning of Forensic Entomology, the science that involves use of insect related evidences in criminal investigation.[1] Over the years, Forensic Entomology diverged into three classes- Stored grain entomology, urban entomology, and medicolegal entomology.[2]

Stored grain entomology, as the name suggests, deals with the investigation of any insect infestation in stored grains, while urban entomology deals with infestation at a household level. Storage grains are plagued most commonly by insects like rice weevil, pulse beetle, and granary weevil, etc. In urban settings, Arthropods such as mites, ticks, cockroaches, lice, and bedbugs etc, spread pathogens and also cause destruction of property. Entomologists can investigate the underlying source of infestation using insects/ insect related evidence.

Medicolegal entomology helps in estimation of the post mortem interval (PMI) and determination of the manner of death amongst other things. It is especially helpful in cases where the early indicators of the PMI can no longer be relied upon. PMI in such situations can be estimated by studying lifecycle as well as successional colonization of insects with time. A cadaver follows a set pattern of putrefactive changes which attract different orders of insects. Usually, the first insects to reach the cadaver belong to the order Diptera (flies). These blow flies, house flies, and flesh flies, lay their eggs around the natural body orifices and open injuries, as they are genetically programmed to lay eggs in nourishment-rich areas for the development of their young. Maggots of these flies attract predatory coleopterans (beetles) and Hymenopterans (ants and hornets). All these insects follow holometabolous/complete metamorphosis which is dependent on a variety of factors such as the geographical location, season, and temperature etc.[3] These factors can significantly alter the PMI and need to be taken into consideration during investigation.

In cases of suspected poisoning, insects and their evidences can help in determining the traces of poisons. Insects feeding on tissues laced with poison, bioaccumulate them throughout their life cycle. These insects, their exuviae, puparia, and faecal matter can be used for toxicological analysis when soft tissues of the cadaver have completely putrefied.

Apart from estimation of PMI, other deductions can be made using the arthropods. Presence of heavy infestation on areas other than natural body orifices may indicate open injuries and wounds on such areas. Geographical location of the commission of crime can be established on the basis of the endemism of the insect. Entomological evidences can assist in indicating whether the body has been disturbed, displaced, or relocated. Insects and their remnants also act as corroborative evidence and help establish a link between the crime scene, perpetrator, and the victim. Neglect and ill treatment of infants and elderly can be diagnosed by detection of the insects on their person.

Over the last few years, there have been tremendous strides in the science of Forensic Entomology. Two of the most notable developments in the past decade are the uses of insects for investigation of wildlife crimes and identification of the victims by mitochondrial DNA profiling of the insect meal. Investigators have successfully determined time since death in poached animals, and apprehended wildlife smugglers and poachers on multiple occasions using the corroborative property of entomological evidences.[4] Mitochondrial DNA has been recovered from meals and excreta of blood sucking insects to identify the host. Human mitochondrial DNA isolated from crops of maggots feasting on human tissues has been identified.[5]

While significant research has been carried out on terrestrial entomology, over the last few years, aquatic entomology has begun to pave its way into investigation of death. Nymphs and adults of dragonflies, damselflies, and mayflies etc. colonize on a body submerged in water. These insects can be used to estimate time since submersion/drowning interval. There have been a few cases reported which state the importance of insects in arson. Even when the cadaver is charred to the bone, puparia and exuviae of insects may survive, and can be used to investigate the death.

Forensic entomology, is thus without a doubt important and useful science in medicolegal investigations. However, insects and their evidences, are often overlooked by the investigating parties. These insects might prove to be the missing piece that

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could potentially direct the investigators towards the right direction. Thus, it is pertinent, that personnel working on the scene of crime and the autopsy surgeons keep an open eye towards any insect related activity, and collect insect evidences so that the medicolegal investigation is done in a holistic way.

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