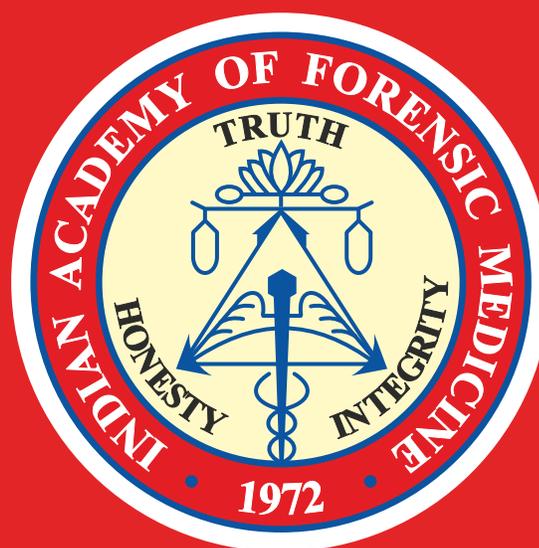


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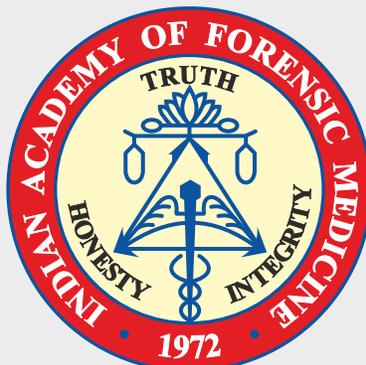
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## Contents

<b>Editorial</b>	1-2
COVID-19 outbreak: A testing time for medicolegal facilities in India <i>Tanuj Kanchan, Ashish Saraf, Sanjeev Misra</i>	
<b>Original Articles</b>	
Analysis of postmortem serum sodium concentration: A way out for determination of time since death? <i>Rina Das, Bhaskar Jyoti Debnath, Pinaki Chakraborty</i>	3-6
An evaluation of medical negligence cases: Role and contribution of medico-legal autopsy <i>Dipak H. Vora, Ankur P. Patel</i>	7-12
A retrospective analysis of project undertaken to curtail the number of post-mortem examinations based on Section 174 CrPC with respect to burn injuries <i>Kavita N Chaphalkar, Indrajit Khandekar, B H Tirpude</i>	13-16
Reliability of Glasgow Coma Scale in Traumatic Brain Injury: A retrospective analysis <i>Hitesh Chawla, Ashish Tyagi, Rajeev Kumar</i>	17-19
Pattern and distribution of skeletal injuries in victims of fatal road traffic accidents <i>Pratibha R. Kulkarni, K. Sankara Narayana, R. B. Kotabagi, Venkatesh Maled</i>	20-23
Epidemiological profile of fatal burn cases in tertiary care centre of Lucknow: An observational study <i>Pradeep Kumar Yadav, Sangeeta Kumari, Anoop Kumar Verma, Raghvendra Singh, Raja Rupani, Shiuli, Richa Chaudhary, Mousami Singh</i>	24-28
Pattern of substance or drug abuse in cases reported by chemical examiner laboratory, Punjab, India <i>Abhey Bansal, Rakesh Gupta, Parminder Singh, Sunita, Gurpreet Kaur, Kamaljit Kaur, Sharanjeet kaur, Darbar Kaur</i>	29-32
Routine preservation of viscera: Is it really required? A Study from Gujarat, India <i>Sanjay Gupta, Utsav Parekh, Chandani Bhatt</i>	33-35
Potential use of cranial morphology in identification of monozygotic twins: A preliminary study <i>Neha Sharma, Shipra Rohatgi, Pooja Puri</i>	36-39
Comparison of morphological measures of nasal bone between genders using computed tomography <i>Sehar Ayub Hasham, Rahul P Kotian, Madhavan TS</i>	40-43

Study of Cephalic Index in medical students of West Bengal <i>Ujwala Bhanarkar, Baishakhi Koley</i>	44-45
Utilization of forensic odontologic findings in solving the unsolved cases: A retrospective study <i>Shivashankar Kengadaran, Joseph John, Divvi Anusha, Sivabalakumaran Kengadaran, Hariharan Sekar, Hemachandran Sekar</i>	46-48
Learning styles of undergraduate medical students – A cross sectional study using VARK questionnaire <i>Abhishek Das, Anamica Chakraborty, Biswajit Sukul</i>	49-53
Assessing the knowledge about Consumer Protection Act and medical negligence in a medical college setting <i>Mallikarjun S Ballur</i>	54-56
<b>Review Articles</b>	
Age, marital status and sexual offences: A “Law Triangle” for women in India <i>Sunil M Doshi</i>	57-62
<b>Case Reports</b>	
The challenges of forensic medical expertise in aircraft accidents: A case report <i>Dalibor Nedić, Vladimir Pilija</i>	63-65
Bite mark analysis: A case report <i>Jimsha VK, Shakila R, Jonathan Daniel M, Ramesh V, Fremingston Marak</i>	66-69
Situs Inversus Totalis: An incidental finding in a fatal case of road traffic accident <i>Vivek Kumar, Gautam Kumar, Rajib Prasad, Prabir Kumar Deb, Rumi Maitra, Madhuri Kumari</i>	70-72
<b>Perspective</b>	
DM in Clinical and Forensic Toxicology: A blueprint <i>Anil Aggrawal</i>	73-74
Advances in firearm serial number restoration <i>Varsha Warriar, Rutwik Shedge</i>	75-76

## COVID-19 outbreak: A testing time for medicolegal facilities in India

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### “Coronavirus is showing us how we've failed to manage the logistics of death”<sup>1</sup>

COVID-19 pandemic has stunned the entire world. Management of the continuously rising number of cases and associated mortalities has come as an unending challenge for the medical fraternity. The outbreak has tested the more robust healthcare system such as in the USA, UK and many parts of Europe, not only with regard to providing basic healthcare services, but also in effective management of the dead. India reported its first case of COVID-19 on 30<sup>th</sup> January 2020. The health authorities in India are on high alert since then. The pandemic has laid bare, the health system deficiencies worldwide. Forensic Medicine/ medicolegal services can be no exception to that. During the COVID-19 pandemic, COVID-19 positive as well as suspect dead bodies are being handed over to district administration and relatives through hospital mortuaries. Forensic Medicine experts thus, have a dual role to play; the traditional one of handling the medicolegal cases, as well as managing the COVID-19 positive and suspect deaths. Effective management of the dead includes not only the dignified handling of the dead but also acting in a manner so as to prevent the possibility of spread of infection to the individuals handling the dead bodies right from the hospital to the crematorium / burial ground and community at large. In this background, there is a need to do a reality check of the existing forensic medicine/ medicolegal facilities in India, and suggest measures to combat the SARS-CoV-2 scare among health care workers.

It would not be incorrect to say that the existing medicolegal facilities in India are largely depleted. The facilities are depleted in terms of trained manpower (number of specialist medical personnel and trained mortuary technicians), as well as infrastructure (mortuary set up, equipment, cold chambers etc.). Most of the doctors who provide medicolegal services at the PHC's and CHC's do not have any formal or specialized training in Forensic Medicine, which is very likely to compromise the quality of medicolegal work being undertaken. The support staff in mortuaries comprise mostly of mortuary attendants, and very rarely technicians. None of whom, have any formal training in this kind of specialized

work. If we talk about infrastructure, the situation is even worse. Mortuaries are devoid of standard autopsy tables, instruments, ventilation, and drainage facilities. At many centres, if not all, autopsies are carried out without any safety precautions, sometimes even with bare hands. There is an acute shortage of the cold chamber units used for the storage of dead bodies. At most of the places, cold chambers are either not available, not in working condition or inadequate for the existing load. Most of the mortuaries in India thus, are working with bare minimum facilities, and manned by untrained individuals. In the existing scenario, it is a challenge to ensure dignified management of dead and that standard precautions and infection control practices are followed.

Owing to the highly contagious nature of the SARS-CoV-2, the significance of following standard precautions and infection prevention and control measures has increased manifold. During COVID 19 outbreak, the health care workers handling the dead bodies in one way or the other, are at risk of getting infected. Likewise, the autopsy room is a place where chances of getting infected are high while autopsies are being carried out, and afterwards. It is a well-established fact that medico-legal autopsies on COVID 19 confirmed/ suspect bodies pose a potential threat of infection to the health care workers. In light of the above, ICMR guidelines suggest that, where ever possible, autopsies should be avoided in COVID 19 cases.<sup>2</sup> However, in absence of mandatory pre-autopsy testing in all the cases planned for autopsy, there is a likelihood of forensic experts and autopsy personnel being exposed to SARS-CoV-2 inadvertently during autopsy. In realization of the fact that COVID 19 is here to stay, and that mandatory pre-autopsy testing for SARS-CoV-2 is unlikely to happen in the near future, it is advisable to consider every autopsy as highly infectious, and follow recommended infection prevention and control measures. Emphasis should be on donning personal protective equipment (PPE) and following standard precautions during autopsy. National and International agencies have issued guidelines on various issues relating to the management of COVID-19 cases. The guidelines are being updated from time to time, and hence, one needs to keep well-informed with the available literature and guidelines, follow these diligently. In this regard, guidelines on management of the dead,<sup>2</sup> environmental cleaning,<sup>2,3</sup> and waste disposal,<sup>4</sup> etc. are available

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for reference. India is a vast country, and practices may vary from place to place. It is hence, suggested to develop region and institute specific guidelines and standard operating procedures in line with the Government of India guidelines and ensure strict implementation of the same.

Some of the issues pertaining to medicolegal facilities, that should have arisen even before COVID-19 pandemic are:

- Is the mortuary well equipped for dignified management of the dead?
- Is the mortuary manned by trained staff to provide quality medicolegal services?
- Are the personal protective equipments available to those working in mortuary at all times?
- Are the standard safety precautions and infection prevention and control practices followed in mortuary at all times?

The answers to the above questions might be a 'NO' for many centres conducting autopsies in India. COVID-19 pandemic is a wakeup call for all forensic experts to seek an affirmative response to these very valid questions. It may require introspection, self-discipline, and raising the issues pertaining to infrastructure and manpower with hospital authorities for taking up corrective measures. The issue of upgradation of mortuaries throughout the country is long pending and need to be addressed. At times one needs to give the best possible services in the limited resources available, but this should not be a norm. By virtue of its functioning, the autopsy room should ideally be equated to an OT. By doing so, a lot of emphasis is laid on infection prevention and control measures and environmental cleaning. AIIMS, Jodhpur can boast of one such mortuary in the country where the standard recommended practices were being followed since its inception. And hence, not much modifications were sought during COVID 19 outbreak. This re-emphasises on the fact that advanced preparedness is the key to effective disaster management.

While there may be centres with scarcity of facilities and personal protective equipment, gloves, and masks, etc., it is not uncommon to see the doctors and morticians ignore the potential risks involved in autopsy, and refrain from utilizing

the available resources appropriately. This exposes them to infections mostly through the aerosols generated during autopsy, or due to contact with body fluids of the deceased. This issue of 'unsafe behaviour' needs to be addressed. It is essential for the autopsy surgeons to develop 'Safety first mindset.' Behavioural changes can be brought about by safety trainings, which should form an essential part of postgraduate training, so that the future experts learn the right things in the right way, early in their career. During the ongoing COVID 19 outbreak, it is important to impart training on various aspects on infection prevention and control measures, and environmental cleaning, to the health care workers including the morticians.

Well established medical institutions in the country, as part of their social and scientific responsibility, should go one step ahead by taking initiatives to share their experiences and train health care workers in newer institutions, CHC's and PHC's on various aspects of management of COVID-19 outbreak. In one such initiative taken by the All India Institute of Medical Sciences, Jodhpur, the health care workers are being trained on various aspects of management of COVID-19 outbreak, including management of the dead, across the entire state of Rajasthan through webinars and online discussions.

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## Analysis of postmortem serum sodium concentration: A way out for determination of time since death?

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### Abstract

Despite a large amount of research undertaken, the post mortem interval remains one of the most challenging variables to be quantified and established. Our project aimed to study the pattern of serum sodium ( $\text{Na}^+$ ) concentration change after death and to correlate it with the post mortem interval. Post mortem blood samples collected from the external jugular vein of a total of 150 subjects with a documented time of death were analyzed in a period of one and half years from January 2017 to June 2018 to assess the changing pattern of  $\text{Na}^+$  concentration to their time since death. Serum  $\text{Na}^+$  concentration was found to be decreased almost linearly with the progression of time within 6-33 hours after death. Coefficient co-relation of mean post mortem  $\text{Na}^+$  concentration and time since death was (-0.96). The average decrease rate of serum  $\text{Na}^+$  concentration was found to be 1.14 meq/L per hour. The present study also showed that a 95% confidence limit of over  $\pm 17.24$  hours limits the usefulness of this method in estimating time since death.

### Keywords

Post mortem interval (PMI); Serum sodium ( $\text{Na}^+$ ) concentration; Time since death (TSD)

### Introduction

Death is not the end, but the beginning for autopsy surgeons in their professional field. Where the manner of death is unnatural, estimated accurate PMI always opens the door of many mysteries. Eyewitnesses and scientific techniques are the two sources for the determination of TSD. Although eye witness testimony plays an essential role in the judiciary system, it is considered one of the most fragile and unreliable evidence because of its uncontrollable dependence upon factors such as age, health, personal bias, perceptions problems, discussion with other witnesses, stress, etc. In this context, Court and Law Agencies are always used to depend on autopsy surgeon, the "Man of Science". But practically no one can deny in spite of tremendous progress in forensic science over the past few decades, time of death is still a "darkspot".<sup>1</sup> Even the present scenario, a considerable range of period is opined based on some gross post mortem external changes such as post mortem cooling, post mortem lividity, the appearance of rigor mortis, stages of decomposition, etc.

An accurate estimation of PMI requires the evaluation of parameters that correlate with time after death.<sup>2</sup> This definition fits well in post mortem changes of biochemical & morphological parameters since each variation has its time factor. These changes begin immediately after death, initiating

at the cellular level and subsequently evolving to hemolysis, discoloration, swelling, and putrefaction. During human decomposition, several biochemical & morphological changes take place in all body tissues due to absence of circulating oxygen and the consequent cessation of aerobic respiration, altered enzymatic reactions, cessation of anabolic production of metabolites, cessation of active membrane transport and changes in the permeability of cells and diffusion of ions.<sup>3-6</sup> Biochemical & morphological profiles from different body fluids can provide insights into the changing metabolic environment of the host. A key advantage of blood from a forensic perspective is that it is a remarkably uniform biofluid, which is largely unaffected by confounding factors such as age, gender, diet, diurnal cycle, and stress, making it ideal to use for PMI determinations.<sup>4</sup> So, the present study was undertaken, and post mortem sodium concentration of blood serum was chosen as a possible biochemical marker for estimation of TSD.

It is known that whatever parameters we use, they are subjected to a wide range of variations and are affected by various factors like the condition of the body, place, environmental condition, cause of death, diseases, etc.<sup>7</sup> So the parameters should be modified depending upon difference in place, seasons, individual characteristics so that TSD can be calculated in a precise, narrow range in a particular case. Due to these variations, the findings of various foreign workers who have worked in different atmospheric conditions and places may not be helpful in solving the day-to-day problems faced by the forensic experts while doing post mortem examination to different places throughout the world. Here in this study, we have exercised the utmost sincerity and care in dealing with every aspect of our topic of research.

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## Materials and Methods

After getting approval from the Institutional Ethics Committee, the present study was conducted for one and a half years as a prospective analytical study over 150 cases from January 2017 to June 2018 in the R.G. Kar Medical College & Hospital Police Morgue attached to the Department of Forensic Medicine & Toxicology and in the laboratory of Department of Biochemistry of the same institution. A stratified random sampling method was chosen to select the study population. One date had been selected by the lottery method from each ten days interval of the entire study period. All the institutional death cases in which time of death is documented, were included. All cases had been accepted on that specific date if satisfied the inclusion criteria. All the cases with external signs of decomposition, the cases in which rigor mortis passed off, newborns, infants, known cases of blood dyscrasia and violent asphyxia deaths were excluded.

Postmortem blood was collected before autopsy by using ten cc syringe with needle from the external jugular vein of each dead body included under study population. The total study population was divided into ten groups based on blood collection time i.e., 6,9,12,15,18,21,24,27, 30 & 33 hours after death — each group comprised of 15cases. Blood samples collected in clotted vials were centrifuged @ 3000 rpm for 3-4 minutes to segregate serum from cellular parts, and serum sodium concentrations were measured by Roche-9180 Electrolyte Analyzer in ion-selective electrode method and derived values were recorded.

After receiving the details, postmortem examination was conducted, and the cause of death was determined. All the findings thus obtained were noted down in a separate Proforma for each case. Then the master chart was prepared. The statistical analysis of the data collection was done and presented in the form of tables & graphs.

## Results

In our study, the total population size that fulfilled all the inclusion & exclusion criteria was 150. The minimum and maximum age of the study population was 14 years & 86 years, respectively. Maximum cases (32cases) were found in 41-50 year age group, and the least cases (10cases) were found in the youngest age group i.e., 1-20 years. The mean age of the study population was 47.26 years and the median was 45 years. Total male population was 90 & female population was 60. Polytrauma was found to be the cause of death in maximum cases i.e., in 30 cases (20% of the total study population) (Table 1 & Table 2).

In the case of both genders, the estimated mean post mortem Na<sup>+</sup>(sodium) concentration was maximum at 6 hours

**Table 1:** Frequency distribution of study population in different age groups

Age range (years)	N	%
1-20	10	6.7
21-30	28	18.7
31-40	22	14.7
41-50	32	21.3
51-60	22	14.7
61-70	14	9.3
>70	22	14.7

**Table 2:** Frequency distribution of the study population based on cause of death

Cause of death at autopsy	N	%
Corrosive ingestion	12	8
Organophosphorus ingestion	12	8
Paraquat ingestion	10	6.7
Viperbite envenomation	8	5.3
Early sequelae of burn	13	8.7
Late sequelae of burn	19	12.7
Head injury	24	16
Polytrauma	30	20
Heart pathology	8	5.3
Lung pathology	8	5.3
Brain pathology	6	4

**Table 3:** Comparative analysis of mean serum Na<sup>+</sup> concentration (meq/L) in males and females with progression of TSD

TSD (hours)	Serum Na <sup>+</sup> in males	Serum Na <sup>+</sup> in females	Student t test
6	117.57	115.50	0.5774
9	114.14	110.63	0.3626
12	102.22	103.67	0.8025
15	98.56	98.67	0.9847
18	98.71	96.75	0.4666
21	93.57	92.00	0.5768
24	91.56	98.33	0.2171
27	87.89	93.67	0.3264
30	90.08	80.00	0.1537
33	86.85	77.00	0.1612

(117.57meq/L in male, 115.50 meq/L in female). As time progressed, mean Na<sup>+</sup> concentration was also changed and hold the lowest value when TSD was 33 hours (86.85meq/L in male,77.00meq/L in female). P-value was>0.05 at all intervals. So, no statistically significant difference exists between the

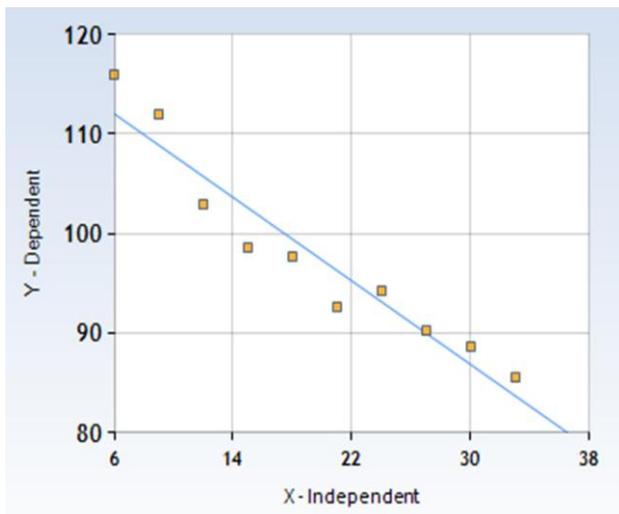
mean Na<sup>+</sup> concentration of male & female blood serum at different intervals after death. So, irrespective of gender, we can compare the recorded values of mean Na<sup>+</sup> concentration measured at different intervals after death from the pooled sex population. (Table 3).

Mean Na<sup>+</sup> concentration was highest i.e.116 meq/L at 6 hours & lowest i.e. 85.5 meq/L at 33 hours. ANOVA test was performed using calculated mean Na<sup>+</sup> concentration values of all specific time intervals, and P-value is 0.000. So the difference among mean Na<sup>+</sup> concentration of each group is statistically significant. But the standard deviation of these mean Na<sup>+</sup> concentrations subsequently increased with the progression of TSD (Table 4).

**Table 4:** Mean serum Na<sup>+</sup> concentration (meq/L) for different TSD in the study sample

TSD (hours)	N	Serum Na <sup>+</sup> concentration	Standard Deviation
6	15	116	6.83
9	15	112	7.18
12	15	103	10.4
15	15	98.6	10.4
18	15	97.7	4.98
21	15	92.7	5.18
24	15	94.3	10.2
27	15	90.2	10.8
30	15	88.7	9.15
33	15	85.5	9.09

A linear regression formula was derived for estimating TSD (X) from Postmortem serum Na<sup>+</sup> concentration (Y) as  $Y=118.34-1.05X$ . Pearson's correlation coefficient (r)=-0.96, implied a strong negative correlation between the two. (Figure 1)



**Figure 1:** Correlation between postmortem mean serum Na<sup>+</sup> concentration (Y) and TSD (X)

The derived linear regression formula may also be read as;  $X = (118.34 - Y) / 1.05$  or  $X = 112.70 - (Y) / 1.05$

Mean of X =19.5 hours, Mean of Y = 97.87 meq/L

Standard deviation (SD) of X =8.62 hours, Standard deviation (SD) of Y = 9.44 meq/L

95% Confidence limit of X= Mean  $\pm$  2 SD of X, i.e. Mean  $\pm$  2x8.62 or Mean  $\pm$  17.24

Regression coefficient (RC) = r x S D of X/ SD of Y. Thus, RC= - 0.96 X (8.62/9.44), i.e. -0.88

This means that a decrease of sodium values of 1meq/L will indicate an increase of 0.88 hours in the postmortem interval, and a 95% confidence limit for all cases will be  $\pm$  17.24 hours.

Thus the average rate of decrease of serum sodium was calculated as 1.14 meq/L per hour.

### Discussion

Serum, one of the major parts of blood, exchanges substance continuously with the interstitial fluid through the pores of the capillary membrane and with the intracellular fluid through the pores of the cellular membrane.<sup>8</sup> Some of those exchanges are energy-dependent, called active transport, and some others are passive transport. Na<sup>+</sup> is the major extracellular cation that differs considerably owing to the activity of various transporters, channels, and ATP driven membrane pump in the living period. After death, there will be cessation of active membrane transport and loss of selective membrane permeability. The passive transport becomes prevalent, and biochemical homeostasis of blood is thoroughly disrupted. That results in electrochemical gradient dependent increased intracellular shifting of Na<sup>+</sup> and ultimately decreases serum Na<sup>+</sup> concentration after death, the autolysis of the capillary membrane is also responsible for its fall.

Coe et al. had pointed out the average rate of postmortem serum Na<sup>+</sup> concentration fall to be 0.9 meq/L per hour in their research.<sup>9</sup> A highly significant correlation between postmortem serum Na<sup>+</sup> concentration & TSD was also documented in our study, and the average rate of fall was 1.14 meq/L per hour.

Singh et al. had demonstrated a highly significant double logarithmic correlation between TSD and serum sodium/potassium electrolytes concentration ratio in humans in Chandigarh Zone of North-West India,<sup>10</sup> but this relationship is also modulated by factors like temperature, age, gender, and cause of death of the deceased. Post mortem serum Na<sup>+</sup> concentration did not show any gender bias in our study, but temperature, age & cause of death might be the confounding factors responsible for a different result.

The present study showed that a 95% confidence limit of over  $\pm$ 17.24 hours limits the usefulness of this method in estimating

TSD. Certain factors have become apparent behind the marked variation in the confidence limits derived from various investigators, especially studying the correlation between TSD and electrolytes concentration in the vitreous humour. These factors can be external such as sampling techniques, different sample size, analytical instruments, and environmental temperature during death or internal factors such as the age of the individual, the duration of the terminal episode, manner of death, electrolyte imbalance and presence of uremia at the time of death.<sup>11</sup> As compared to serum, the vitreous humour of the eye is stable and less susceptible to rapid chemical changes and contamination. So, it is expected, these above mentioned unavoidable confounding factors play a crucial role for a 95% confidence limit of over  $\pm 17.24$  hours in our study.

Postmortem serum sodium concentration may be influenced by various pre-morbid conditions such as dehydration, NaCl poisoning, salt water drowning etc. These factors may cause limitation to use serum sodium concentration as a TSD marker.

## Conclusion

It's high time to search for other possible objective biological parameters for estimation of PMI. Postmortem serum Na<sup>+</sup> concentration has the potential to play a decisive role in this context. According to our study findings, postmortem serum Na<sup>+</sup> concentration formulated a linear regression curve with TSD, and the average rate of fall was 1.14 meq/L per hour. 95% confidence limit of over  $\pm 17.24$  hours limits the usefulness of this method in estimating TSD. The role of various confounding factors needs to be evaluated more precisely before its use in the practical field. However, its use should be adjuvant to other methods. Also, one should keep a check on the method of analysis, as it can make a difference in the final results.

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

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## An evaluation of medical negligence cases: Role and contribution of medico-legal autopsy

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### Abstract

Autopsy based forensic evaluations are critical to the final outcome of medical negligence cases. It is imperative that autopsy surgeon is aware of clinical issues and should plan autopsy dissection with respect to those issues. This study is aimed to determine the role of medico-legal autopsy in the ascertainment, assessment and evaluation of the medical negligence cases. In this retrospective study, total 61 medico-legal autopsy cases involving medical negligence claims were studied. Cases were classified according to type of health care facility, type of medical or surgical specialty as well as discrepancies between clinical and autopsy diagnosis and type of medical error involved. Surgical branches (82%) are more involved in alleged medical negligence cases than medical branches (18 %). 33 % cases are of Obstetrics & Gynecology followed by Anesthesia (29 %), and Surgery (20 %). In majority of cases (65 %), small private hospitals with less than 100 beds (type C) are involved. Act of commission was found in 26 % cases. Act of omission was claimed in 7 %. In 18 % cases there was a failure to diagnose major disease in pre-anesthetic and pre-operative check up. In 8 % cases wrong diagnosis was claimed. In one case, nursing staff has given wrong drug to the child led to the sudden death. In 13 % cases death occurred due to known complications. Present work indicates that early post-mortem examination in alleged medical negligence cases provides new and unrecognized information of great assistance in determining the cause of death.

### Keywords

Medical negligence; Medico-legal autopsy; Forensic evaluation; Contribution

### Introduction

Medical negligence, now days have become one of the serious issues in India. With the increasing awareness in the society and the people in general, gathering consciousness about their rights, large number of complaints against doctors are being filed in to the consumer forums. Criminal complaints are also being filed against doctors alleging commission of offences punishable under section 304 (A) or Sections 336/337/338 of the IPC. Negligence by doctors has to be determined by judges who rely on expert's opinion and decide on the basis of basic principles of reasonableness and prudence.<sup>1</sup> Outcome of a malpractice case may depend on the quality of the autopsy, specifically on the awareness of the autopsy surgeon of clinical issues, particularly those that are of potential medico-legal interest, and the thoroughness of the autopsy dissection with respect to that issues.<sup>2</sup>

The goal of autopsy performance is not limited to identification of the immediate cause of death, but should include an effort to identify processes that correlate with all known potentially significant facts in the medical record.<sup>2</sup> Before starting the autopsy, chronological synopsis of essential clinical events should be extracted from the medical records. It is helpful to know the questions posed by clinicians and to address each one

during the dissection, when choosing samples for microscopy, and in the final report. Many studies have documented that major discrepancies are common between diagnosis entered on the death certificates and autopsy diagnosis.<sup>2</sup>

The earliest medico-legal autopsies performed on patients who died postoperatively provide new and often unexpected information of great assistance in identifying the cause of death. Most of the diagnoses performed by the clinician in charge of the patient at the time of death are wrong. The new information provided by the autopsy can influence the treatment decision in some cases. In the cases in which the autopsy provided a diagnosis which was not been suspected pre-mortem, changes in perioperative management can modify the prognosis. Various reports demonstrate the extremely high yield of early autopsies performed in the case of postoperative death with suspicion of malpractice. They frequently identified undetected complications and disease processes. They can also suggest faulty or negligent practice that would otherwise go unrecognized.<sup>3</sup>

Autopsy can also help conflict solving: when the family suspects that malpractice has occurred, they are unlikely to believe the explanations provided by the physician to justify his management of the case, and in this situation, an autopsy can restore trust and resolve conflicts by providing data viewed as objective by the family. In this situation, performing an autopsy can avoid litigation. Autopsy can also help to identify inappropriate and hazardous practices with the goal of improving the safety of future patients.<sup>3</sup> This study is aimed to determine the role of medico-legal autopsy in the ascertainment, assessment and evaluation of the medical negligence cases. By doing complete and thorough autopsy,

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careful formation of opinion and giving evidence in to the court of law, Forensic Medicine Expert can help the law enforcement agencies in the investigation and help the court in administration of justice in medical negligence cases.

The present study was conducted to examine the distribution of medical negligence cases according to involved health care facilities and specialties, and to find out the role of autopsy in discovering major undiagnosed pre-existing disease in medical negligence cases. The study also attempts to identify the discrepancies between clinical and autopsy diagnoses of cause of death, and the types of medical errors.

## Materials and Methods

In this retrospective study, a total 61 medico-legal autopsy cases involving medical negligence claims were studied. These cases were referred to The Forensic Medicine Department of a medical college affiliated with a tertiary care hospital over a period of five years from January, 2014 to December, 2018.

Medico-legal autopsy cases showing clear history of medical negligence claims in police papers are included in this study and all other cases are excluded. Information and data are collected from police papers, hospital records as well as from the autopsy report, and reports of ancillary investigations. Observed data are tabulated and plotted on the charts. These data are compared with the other research works having similar objectives. Conclusions are drawn at the end regarding the role of medico-legal autopsy in medical negligence cases.

1. Classification of involved Health Care Facilities:<sup>3</sup> in to four categories as follows

Type A: Hospitals or medical centers affiliated with well known universities, with significant teaching and research as a part of their core mission.

Type B: Larger hospitals or medical centers with more than 100 beds and minimum capacities for higher level care.

Type C: small hospitals with less than 100 beds and minimal capacities for higher level care, such as township hospitals or community health centers.

Type D: small family or private clinics with no inpatient beds that can only perform simple clinical care.

2. Physician Specialty: Physician Specialties were classified as obstetrics & gynecology, anesthesia, surgery, internal medicine, pulmonary medicine, and other systems of healing such as ayurveda, naturopathy, as well as paramedical professions e.g. nursing.

3. Discrepancies between clinical and autopsy diagnoses were classified by the following criteria:<sup>3</sup>

i. Correct diagnosis: Clinical diagnoses correctly matched diagnoses at autopsy.

ii. Incorrect diagnosis: Unknown major clinical diagnoses which were disclosed at autopsy.

iii. Indeterminate: Cause of death was clinically uncertain, or cause was suspected but could not be clearly diagnosed and confirmed.

4. Classification of Medical Errors:

Medical errors were classified in to 5 groups as previously described by Madea and Preuss:<sup>3</sup>

i. Negligence: such as omission of necessary treatment or therapeutic omissions, delayed admission to hospital, and insufficient diagnostics.

ii. Preventable complications at and / or after surgery, perioperative complications.

iii. Wrong treatment, inappropriate treatment.

iv. Mistakes in care, suboptimal care.

v. Adverse drug events, medication errors, such as wrong drug or dose, wrong application, disregarding drug allergy, and illegible medication.

## Results

Total 61 cases of death due to alleged medical negligence were studied. The age at death ranged from newborn to 75 years. 51 % cases were female and 49% were male. 72 % females are in the reproductive age group i.e. 20 to 40 years due to obstetrical and gynecological complications. Total number of females is slightly more than male cases due to the same reason with male: female ratio is 0.9:1. Males are evenly distributed in all age groups. Maximum cases of alleged medical negligence occurred in Obstetrics & Gynecology (33 %), followed by Anesthesia (29 %), and Surgery (20 %). In anesthetic cases also, 5 cases were of Obst. & Gynec for which anesthesia was required. It is clearly indicated that surgical branches (82%) are more involved in alleged medical negligence cases than medical branches (18 %). Compare to the Government hospitals (22 %); private hospitals (78 %) are more involved in alleged medical negligence cases. Small private hospitals with less than 100 beds (type C) are mostly involved (65 %).

Act of commission was found in 26 % cases. From our study it is evident that, in surgical branches (Obst. & Gynec and Surgery), intestinal perforation (n=7 cases, 44 %) during surgery was most common surgical error found during autopsy, followed by injury to the internal visceral organs (n=4 cases, 25 %), injury to the major blood vessels (n=3 cases, 19 %). Only in one case we have found an evidence of retained instrument in the abdominal cavity during surgery ("Res Ipsa Loquitur"). Act of omission (no treatment or delayed treatment or lack of adequate precautions) was claimed in four cases (7 %). In five cases (8 %), wrong diagnosis was claimed. All these five cases

were belonging to the specialty of Internal Medicine. In all these five cases, autopsy revealed the acute coronary insufficiency as a cause of death. In one case, nursing staff has given wrong drug to the child led to the sudden death (“Res Ipsa Loquitur”). In 13 % (n=8) cases death occurred due to known complications.

**Table 1:** Age and sex distribution of cases

Age range	Male	Female	Total
0 -10	6 (10 %)	0 (0 %)	6 (10 %)
11-20	2 (2 %)	1 (2 %)	3 (4 %)
21-30	4 (8 %)	13 (20 %)	17 (28 %)
31-40	5 (9 %)	10 (17 %)	15 (26 %)
41-50	5 (9 %)	5 (9 %)	10 (18 %)
51-60	2 (2 %)	2 (2 %)	4 (4 %)
>60	5 (9 %)	1 (1 %)	6 (10 %)
Total	29 (49 %)	32 (51 %)	61 (100 %)

**Table 2:** Distribution of cases according to specialty involved

Specialty	Total
Obst. & Gynec	21 (33 %)
Anesthesia	17 (29 %)
Surgery	12 (20 %)
Internal Medicine	7 (10 %)
Pulmonary Medicine	1 (2 %)
Non - allopathic or Quacks	2 (4 %)
Nursing	1 (2 %)
Total	61 (100 %)

Out of total 61 cases, in 20 cases (33 %) autopsy revealed presence of some disease which had not been suspected pre-mortem. In 11 out of 61 cases (18 %), there was a failure to diagnose major disease in pre-anesthetic and pre-operative check up. It can be safely concluded from above findings that, in 11 cases (18 %) in which the autopsy provided a diagnosis which had not been suspected pre-mortem, changes in perioperative management would have modified the prognosis. In our study, out of total 20 cases (33 %) of discovery of unrelated major disease at autopsy, in 10 cases coronary atherosclerosis with narrowing and / or left ventricular hypertrophy were seen. While in 3 cases, pulmonary thrombo-embolism was discovered at autopsy. In two cases chronic renal disease and in another two cases chronic lung disease was discovered. In Obst & Gynec cases, HELLP was discovered in two cases; while three cases AFLP (Acute Fatty Liver of

Pregnancy), AFES (Amniotic Fluid Embolism Syndrome) and Abruptio Placentae were discovered respectively at autopsy.

In our study, out of total 61 cases, in 32 cases (51 %) clinicopathological discrepancy in cause of death was discovered. Medico-legal autopsy revealed new cause of death which was not suspected by the treating doctors. This clearly indicates importance of medico-legal autopsy in medical malpractice claims.

**Table 3:** Distribution of cases according to type of Health Care Facilities

Health Care Facility	Private	Government/ Municipal	Total
A	3 (5%)	9 (16%)	12 (21%)
B	1 (2%)	2 (3%)	3 (5%)
C	41 (65%)	2 (3%)	43 (68%)
D	3 (6%)	0 (0%)	3 (6%)
Total	48 (78%)	13 (22%)	61 (100%)

**Table 4:** Distribution of cases according to disclosure of undiagnosed pre-existing disease at autopsy:

Specialty	Total cases	New disclosure at autopsy
General Anesthesia	8	4
Spinal Anesthesia	9	2
Internal Medicine*	11	5
Obstetrics & Gynecology	21	5
Surgery	12	4
Total	61	20

\*- including cases of pulmonary medicine, quacks and nursing negligence

**Table 5 :** Distribution of cases according to type of error

Type of Error	Obstetrics & Gynecology	General Anesthesia	Spinal Anesthesia	Internal Medicine	Surgery	Total
Act of Commission*	8	0	0	1	7	16
Act of Omission**	2	0	0	2	0	4
Wrong diagnosis	0	0	0	5	0	5
Failure to diagnose major disease during PAC#	4	4	1	0	2	11
Wrong Drug	0	0	0	1	0	1
Adverse Drug Reaction	0	0	0	1	0	1
None	6	0	0	1	1	8
Undetermined	1	4	8	0	2	15
Total	21	8	9	11	12	61

\* - Perforation of intestine, injury to viscera or blood vessels, retained instrument or gauze piece, ventilator pressure induced pneumothorax

\*\* - No treatment or delayed treatment, failure to adopt adequate precautions

# - Preoperative & Pre-anesthetic check up

**Table 6 :** Distribution of cases according to clinico-pathological discrepancies in cause of death

Specialty Involved	Total Cases	Correct Diagnosis	Incorrect Diagnosis	Indeterminate
General Anesthesia	8 (100%)	0 (0 %)	4 (50 %)	4 (50 %)
Spinal Anesthesia	9 (100%)	2 (22 %)	2 (22 %)	5 (56 %)
Internal Medicine*	10 (100%)	3 (30 %)	5 (50 %)	2 (20 %)
Obst. & Gynec	21 (100%)	6 (29 %)	13 (62 %)	2 (9 %)
Surgery	12 (100%)	3 (25 %)	8 (67 %)	1 (8 %)
Pulmonary Medicine	1 (100%)	1 (100 %)	0 (0 %)	0 (0 %)
Total	61 (100%)	15 (26 %)	32 (51 %)	14 (23 %)

\* - Including cases of quacks and nursing negligence

## Discussion

In our study, most of the females (72 %) are in the reproductive age group 20 to 40 years due to obstetrical and gynecological complications. Total number of females is slightly more than male cases due to the same reason with male: female ratio is 0.9:1. Males are evenly distributed in all age groups. He Fanggang et al<sup>4</sup> in their study of Medical Malpractice in Wuhan, China found distribution of medical malpractice cases as follows: A total 190 medical malpractice claims were evaluated by them. The age at death ranged from newborn to 85 years. Male patients were more common with a male: female ratio was 1.6:1. Patients < 18 years and those between 30-50 years were two most common age groups. In our study 54 % cases were belonged to the age group 20-40 years. Among the 36 medical negligence cases studied by Edulla N.K. et al<sup>5</sup>, 6 (17 %) cases were under 18 years of age, and 30 (83 %) cases were older than 18 years. Among them, 18 (50 %) cases were female and another 18 (50 %) cases were male subjects. In a study by Yazici Y.A. et al<sup>6</sup>, of the 330 cases with medical malpractice claims within a period of 11 years between 2000 and 2011, 165 cases were female, 164 were male, and one case was hermaphrodite. Mean age of the cases was 28, and 12.7 % of the cases were 1 year of age or younger. In the study by Hassan DAE et al<sup>7</sup>, neonates were 14.5 % of all cases (35 out of 243) while the majority of patients were younger than 45 years (165 out of 243). The majority of patients were males (55.6 %).

In our study, the maximum cases of alleged medical negligence occurred in Obstetrics & Gynecology (33 %) followed by Anesthesia (29 %), and Surgery (20 %). In anesthetic cases also, 5 cases were of Obstetrics and Gynecology for which anesthesia was required. It is clearly indicated that surgical branches (82%) are more involved in alleged medical negligence cases than medical branches (18 %). In the study by He Fanggang et al.,<sup>4</sup> general practitioners faced the highest number of malpractice claims (n= 56), followed by the surgery (n= 43) and internal medicine (41 claims). Among the 36 cases

of medical negligence studied by Edulla et al<sup>5</sup>, 18 (50 %) cases were medically related and another 18 (50 %) cases surgically related. In a study by Yazici et al<sup>6</sup>, considering the medical specialties, Gynecology and Obstetrics (94) was the leading specialty, followed by General Surgery (60), Orthopedics (41), ENT diseases (22), and Anesthesiology (21). In the study by Hassan et al,<sup>7</sup> surgery is at the top of the medical specialties involved (27 %), followed by Obstetrics (20.99 %), Anesthesia (12.76 %) and pediatrics (10.29 %).

In our study, Compare to the Government hospitals (22 %), private hospitals (78 %) are more involved in alleged medical negligence cases. Small private hospitals with < 100 beds (type C- 65 %) are mostly involved. In the study by He Fanggang et al<sup>4</sup>, upper-tier (types A and B) hospitals were involved in more malpractice claims (59.5 %). In a study by Yazici Y.A. et al<sup>6</sup>, in 40.3 % of the cases, individuals were referred to a state hospital for health care services, in 39.1% to a private hospital, 9.1 % to other healthcare institutes, 6 % to universal hospitals, and 5.5 % to clinics for out-patients. In a study by Hassan et al<sup>7</sup>, the criminal proceedings were mainly against public hospital doctors, and near one third of the cases were against private hospitals, with a small percentage (3 %) of cases involving doctors in private practice.

In the study by He Fanggang et al<sup>4</sup>, of the 97 approved malpractice cases, medical errors included negligence (group 1), surgical complications (group 2), wrong treatment (group 3), mistakes in care (group 4), and adverse drug events; among these errors, groups 1, 2, and 5 were most common, accounting for 50.5 %, 18.6 %, and 19.6 % cases, respectively. Among the 36 cases of medical negligence studied by Edulla et al<sup>5</sup>, in 6 (17%) cases cause of death was not opined from post-mortem findings. In 12 (33 %) cases, the cause of death was drug hypersensitivity; in three (8 %) cases, known adverse effects of drug; in 9 cases, hemorrhage; and, in 6 cases, other causes. Proof of negligence was found only in 21 (58 %) cases, and it was not found in 15 (42 %) cases. In a study by Yazici et al<sup>6</sup>, the leading harm and injuries in cases which claimed medical malpractice were deaths allegedly due to lack of treatment, lack of care (39.7 %), followed by nervous system injuries (12.1 %), organ perforations and organ loss (10.9 %), incomplete recovery (7.9 %), and skeletal system injuries (7 %). In a study by Hassan DAE et al<sup>7</sup>, Negligence was found in maximum cases (31 %), followed by complication within surgical interference in 15.4 % cases, anesthetic mishaps in 10 % cases and medication errors in 28.6 % cases. In our study, act of commission was found in 16 (26 %) cases. It is evident from our study that, in surgical branches (Obst. & Gynec and Surgery) intestinal perforation (n=7 cases, 44 %) during surgery was most common surgical error found during autopsy, followed by injury to the internal visceral organs (n=4 cases, 25 %), injury to the major blood vessels (n=3 cases, 19 %). Only in

1 case we have found an evidence of retained instrument in the abdominal cavity during surgery (“Res Ipsa Loquitur”).

In one case of pulmonary medicine, patient was on ventilator and due to inadvertent increase in the pressure he developed fatal pneumothorax and subcutaneous emphysema. In 11 out of 61 cases (18 %), there was a failure to diagnose major disease in pre-anesthetic and pre-operative check up. In 6 cases of death associated with anesthesia, in 4 cases cardiac disease (severe atherosclerosis of coronary arteries with or without left ventricular hypertrophy) was found during autopsy which remained undiagnosed preoperatively. In one of those cases chronic pyelonephritis was also found with left ventricular hypertrophy. In 2 cases of anesthetic deaths, evidence of severe chronic lung disease was detected during autopsy which remained undiagnosed preoperatively. In four cases of Obst & Gynec specialty, in two cases HELLP was detected during autopsy while in one case AFLP and in another case abruption placenta was detected during autopsy. In one case of surgery, severe LVH with coronary atherosclerosis was discovered during autopsy and in another case renal disease was discovered.

It can be safely concluded from above findings that, in 11 cases in which the autopsy provided a diagnosis which had not been suspected premortem, changes in perioperative management would have modified the prognosis. Act of omission (no treatment or delayed treatment or lack of adequate precautions) was claimed in four cases. In two cases antibiotic injection was given intra-muscularly in buttocks followed by cellulites and necrotizing fasciitis. In both these cases injection was given by unqualified persons who may have not taken adequate aseptic precautions. These two cases are also belonged to the category of “Res Ipsa Loquitur”. In another two cases belonging to Obst & Gynec specialty, after delivery of new born baby, no pediatrician was made available. Due to night hours of delivery, it is possible that no doctor was present.

In five cases, wrong diagnosis was claimed. All these five cases were belonging to the specialty of Internal Medicine. In all these five cases, patient was came with vague symptoms i.e. vomiting, burning epigastrium, back pain etc. which was wrongly diagnosed by the attending doctor as gastritis or something else. Patients were given symptomatic treatment and sent back to home followed by brought dead to the hospital. In all these five cases, autopsy revealed the acute coronary insufficiency as a cause of death. In one case, nursing staff has given wrong drug to the child led to the sudden death (“Res Ipsa Loquitur”). Adverse drug reaction (fatal anaphylactic reaction) was found in one case due to intravenous injection of metrogyl. Life saving drug adrenalin was not given by the physician and patient was died within fifteen to twenty minutes.

In eight cases death occurred due to known complications or natural disease and no error on the part of attending doctor was

found. Maximum number, 6 cases were belonging to Obst & Gynec specialty. In three cases atonic PPH was found to be a cause of death, in two cases AFES (Amniotic Fluid Embolism Syndrome) was a cause of death. In one case of ERCP, patient developed ERCP pancreatitis which is a known complication. In one case of Internal Medicine, patient was given iron sucrose injection for treatment of severe anemia. He was sent back to home. Sudden death occurred during the way to the home. Relatives made an allegation that death occurred due to some reaction to the iron-sucrose injection. Medico-legal autopsy revealed that death was due to acute coronary insufficiency and no any evidence of drug reaction was found. In one case of Obst & Gynec, relatives had made allegations that injuries are present over the dead body of the newborn infant. They alleged that these injuries occurred during delivery and responsible for death. The medico-legal autopsy revealed that those injuries are actually signs of maceration and fetus was dead born. This clearly indicates that medico-legal autopsy can also help conflict solving.

In the present study, out of total 61 cases, in 20 cases (33 %) autopsy revealed presence of some disease which had not been suspected premortem. Changes in perioperative management would have modified the prognosis in some of these cases. In 10 cases coronary atherosclerosis with narrowing and / or left ventricular hypertrophy were seen. While in 3 cases, pulmonary thrombo-embolism was discovered at autopsy. In two cases chronic renal disease and chronic lung disease were discovered respectively. In Obst & Gynec cases, HELLP was discovered on two cases; while three cases AFLP (Acute Fatty Liver of Pregnancy), AFES (Amniotic Fluid Embolism Syndrome) and Abruptio Placentae were discovered respectively at autopsy.

Juvin et al<sup>3</sup> demonstrate the extremely high yield of early postmortem autopsies performed in the case of postoperative death with suspicion of malpractice. Early autopsies frequently identified undetected complications, including surgical complications and disease processes. They could also suggest faulty or negligent practice that would otherwise go undetected.

In our study, out of total 61 cases, in 32 cases (51 %), medico-legal autopsy revealed new cause of death which was not suspected by the treating doctors. In 15 cases (26 %), apparent cause of death suspected by the treating doctors was confirmed at autopsy. In 14 cases (23 %), treating doctor was not sure about the cause of death, so clinically cause of death remained indeterminate even though it may have been discovered during autopsy. So, our study shows high degree of discrepancies between clinical and autopsy cause of death in medical malpractice cases. This shows importance of medico-legal autopsy in medical malpractice claims.

Discussion between pathologist, surgeon and anesthetist may arrive at an amicable conclusion that will be the best consensus of opinion to offer the investigating authority in cases of anesthetic

deaths where a bare autopsy might reveal little or nothing upon which to base any interpretation of the fatal processes.<sup>8</sup>

## Conclusions

With the increase in medical negligence litigation, forensic medicine expert has got a greater role to play. In case of death owing to medical negligence, it is him to say the exact cause of death and its relation to the act of omission or commission. It is difficult for forensic medicine experts to keep abreast of all the developments in various specialty techniques; hence, it is better forming an adhoc committee, which could be composed of virtually any combination of specialists to evaluate a case of medical negligence. The precise evaluation of autopsy reports in cases of medical malpractice is also a task of forensic medicine as a contribution to increase patient safety by the identification and reporting errors. Medico-legal autopsy can also help conflict solving: when family suspects that malpractice has occurred, they are unlikely to believe the explanations provided by the physician to justify his management of the case, and in this situation, the medico-legal autopsy can restore trust and resolve conflicts by providing the data viewed as “objective” by the family. In this situation performing an autopsy can avoid litigation. In agreement with previous studies, the new information provided by the autopsy which had not been suspected pre-mortem could have influenced treatment decision and would have modified the prognosis in some cases if they have been recognized clinically. Most early post-mortem autopsies performed on patients who died postoperatively provide new and often unexpected information of great assistance in identifying the cause of death.

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

**Conflict of interest:** None to declare.

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## A retrospective analysis of project undertaken to curtail the number of post-mortem examinations based on Section 174 CrPC with respect to burn injuries

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### Abstract

A project was implemented at MGIMS, Sevagram from 2016 onwards based on Section 174 CrPC to curtail the avoidable cases of post-mortem examination without violating the law. Under this project, police were directed to use modified formats for inquiry or investigation into the cause of deaths i.e., commonly known as inquest. Modified inquest format mandates to mention the cause of death if it is certified by the treating doctor and also the reason/s for forwarding the case for post-mortem examination as per subclauses under Section 174(3) CrPC.

The aim of current study was to analyse outcome of this project with respect to number of post-mortem examinations in cases of burn injuries. Data of all cases of burn admitted and died while under treatment at the hospital during period from 2013 to Sep' 2018 was gathered from 'Hospital Information System' and Computerized Autopsy reports and retrospectively analysed using Microsoft Office 2007 excel worksheet. There were 287 deaths due to burn injuries during the study period. Out of these 287 deaths, 178 cases were during the period 2013-2015. Out of these 178 cases, 176 (98.88%, n= 178) cases were forwarded by police for post-mortem examination. Out of 287 deaths, 109 cases were during the period 2016-2018 with number of cases forwarded by police for post-mortem examination was 56 (51.38%, n=109). This indicates that there is decrease in number of cases for post-mortem examination after implementation of the project without violating the provisions of Section 174 CrPC.

### Keywords

Section 174 CrPC; Burn injuries; post-mortem examination

### Introduction

Section 174 CrPC<sup>1</sup> (Code of Criminal Procedure) describes the procedure of enquiry and preparation of report of the apparent cause of death by the police in cases of alleged suicide, homicide, deaths due to animal or machinery, accidental deaths and suspicious deaths. This is commonly referred as inquest. As per this section, the police officer, investigating the case of such deaths, commonly referred as investigating officer (I.O.), is empowered to forward such body for medical examination (which is routinely considered as post-mortem examination) to the nearest civil surgeon, or other qualified medical man appointed in this behalf by the state government (RMP), if there is any doubt regarding the cause of death; or for any other reason the police officer considers it expedient to do so. Cases of sudden, suspicious or unnatural deaths occurring in hospitals or deaths in medico-legal cases or cases brought dead to the hospitals are routinely reported to police for further investigations. After receiving information of such deaths from the hospitals, the police, again, as per Section 174 CrPC, start inquiry along with other applicable provisions / sections of law.

As per Section 10(3) of Registration of Births and Deaths Act, 1969<sup>2</sup>, the medical practitioner is bound to give the medical certificate of cause of death (MCCD), to the best of his knowledge and belief, if he has attended the deceased during his last illness. There is no law which prohibits the medical practitioner from issuing a MCCD, if he is sure about the cause of death, based on available medical evidence<sup>3,4</sup>. This is applicable to medico-legal cases as well. In other words, there is no legal provision not allowing the medical practitioner to issue the MCCD in medico-legal cases. Even government has not issued any circular or directions that prohibit doctors and medical practitioners from issuing MCCD in medico-legal cases<sup>4</sup>. The only precaution one must take is not to hand over the body along with the MCCD to the relatives in such cases.

The MCCD is a document which is used for various purposes and its utility ranges from insurance claims to its impact on international health statistics and policies. It has an important role to play in medico-legal cases as documentary evidence. There are legal provisions and government guidelines<sup>3</sup> as well to help the medical practitioner to fulfill his duty of completing the MCCD correctly. Two main aspects are important- 'how to fill the MCCD' and even before it, 'in which cases, the MCCD is to be filled'. However, many studies, done so far, have shown that there is still a lot of scope for improvement<sup>5,6</sup>.

This makes it necessary at institutional level, to make sure, that the document is filled properly so that it can be utilized in maximum possible ways for various purposes. By making use of the MCCD and provisions of Section 174 CrPC, the project

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was started at tertiary Care Hospital with the purpose of curtailing avoidable cases of post-mortem examination without violating the provisions of Section 174 (3) CrPC. This project was started in 2016. A District-level committee was formed under the chairmanship of Superintendent of Police, District Wardha. This committee formulated the guidelines for the project and the same were communicated officially through the office of the superintendent of police to the concerned police stations and to all concerned departments of the hospital.

According to these guidelines, routine formats which police had been using for the procedure of inquiry and preparation of report stating the apparent cause of death under Section 174 CrPC were modified as follows and includes: Details of death including MCCD (Appendix I), reasons to send the case for post-mortem examination as per Section 174(3) CrPC (Appendix II) and No Objection Certificate (NOC) from relatives and police (Appendix III and IV respectively).

With the implementation of this project, the I.O started to check details of death including cause of death furnished in MCCD by the treating doctor. Then, based on investigations, available documents and provisions under Section 174 (3) CrPC, the I. O. would decide whether to forward the case for post-mortem examination or not. The guidelines further mandates that if the case is to be handed over to relatives by police without forwarding for post-mortem examination as per the discretionary power given to I.O. under Section 174 CrPC then it must be with NOC (no objection certificate) from the relatives (next of kin / legal heir). At the same time police also must give NOC to the relatives to the effect that the post-mortem examination was not done as there was no doubt in cause of death and other necessary documents including MCCD for further rituals.

The project involves all cases of deaths but the study was focused exclusively on cases of burn injuries. The present study aimed at analysing the outcome of the above detailed project in cases of burn injuries. The objectives of the study were; to assess the change in quantity of work after implementation of the project, assess further scope of project and give suggestions based on analysis.

## Material and Methods

The study is a retrospective analysis of 6 years, 3 years prior to the project and 3 years after implementation of the project, from 2013 to September 2018. The data collection and analysis was done during the period from August 2018 to October 2018. The data required for the study was gathered from Hospital Information System (HIS), Software designed exclusively for 'MCCD', Computerised post-mortem examination reports and police papers.

While collecting the data, date of discharge / death was taken into consideration to keep the uniformity in records. The data, thus, collected was further analyzed using 'Microsoft Office 2007 excel worksheet'. During this analysis, pre-decided

inclusion and exclusion criteria were strictly followed. All cases of burn injury (dry heat) died in the hospital as in-door patients during the study period were included in the analysis. Those excluded were the burn patients who had been brought dead to the casualty, or who died in the hospital before admission (OPD cases), or those who died outside the hospital and were brought exclusively for post-mortem examination. The exclusion was based on lack of MCCD in such cases.

## Results

During the period 2013-2015, total number of deaths in cases of burn patients admitted at the hospital was 178. Out of these 178 deaths informed to police, the number of cases forwarded for post-mortem examination by police was 176 (98.88%, n=178) cases as shown in Table I.

After implementation of project, during the period 2016-18, total number of deaths in cases of burn patients admitted at the hospital was 109 and again all were informed to police. Out of these 109, the number of cases forwarded for post-mortem examination by police was 56 (51.38%, n=109) cases (Table 1).

**Table 1:** Outcome in terms of total number of post-mortem examination cases

Project status	Deaths informed to police	Cases sent for post-mortem examination by police
Not implemented (2013-2015)	178	176 (98.88%)
Implemented (2016-2018)	109	56 (51.38%)

Out of 176 cases forwarded by police during the period 2013-2015, in 173 (97.19%, n=176) cases, the cause of death was given in MCCD format by the treating doctors. Out of 56 cases forwarded by police during the period 2016-2018, in 39 (69.64%, n=56) cases, the cause of death was given in MCCD format by the treating doctors. while in 17 (30.36%, n=56) cases, the reason for post-mortem examination was to find out the cause of death. In 39 cases where the cause of death was already certified by treating doctors, the reasons for post-mortem examination were based on Section 174 (3) CrPC. There are total 5 sub-clauses in this subsection 3. Out of these 5 reasons, 1 (2.56%, n=39), 5 (12.82%, n=39), 1 (2.56%, n=39), 18 (46.15%, n=39) and 10 (25.64%, n=39) cases were done for reason No. i, ii, iii, iv and v, respectively. In 4 (10.26%, n=39) cases, no reason was specified by the I.O. (Table 2).

**Table 2:** Analysis of the reasons given by police for conducting post-mortem examination as per S 174 CrPC during 2016-2018

Cases with MCCD issued	i	ii	iii	iv	v	NR
39	01	05	01	18	10	04

The Investigating officers handed over 53 (48.62%, n=109) cases to the relatives without forwarding them for post-mortem examination during the period of 2016-2018.

## Discussion

During both the periods, before and after implementation of the project, all deaths in cases of burn injury patients admitted at the hospital were informed to police as per policy of the hospital. In first half of study period, from 2013 to 2015, out of 178 deaths informed to police, almost all the cases, 176 (98.88%, n=178), barring 2, were forwarded for post-mortem examination by police. In two cases, the reason for not forwarding the cases for post-mortem examination could not be found out. This was done as per routine practice of the police to forward all the bodies for post-mortem examination indiscriminately which had been informed to them by hospital. However, this got changed after implementation of project as the project encouraged use of powers of police which are provided to them under S 174 CrPC to discriminate the cases based on their investigations. Therefore, in later half of study period, during the period 2016-18, when the project was started, though all the deaths in cases of burn patients admitted at the hospital were informed to police, police have forwarded only 56 (51.38%, n=109) cases for post-mortem examination. The need of post-mortem examination was decided by police based on available documents including MCCD. The procedure of enquiry and preparation of report stating the apparent cause of death in these 109 cases was done as per the modified format.

In another aspect of analysis, when the total cases forwarded for post-mortem examination were analysed, it was observed that, before implementation of project, out of 176 cases which were forwarded by the police for post-mortem examination, in 173 (97.19%, n=176) cases, though the cause of death was given in MCCD format by the treating doctors, the reason for post-mortem examination, in all these cases, given by the I.O was to find out the 'Cause of death' (COD). With change in policy of police, after implementation of project, the post-mortem examination was asked for on the basis of provisions given under S 174 (3) CrPC. Accordingly, out of 56 cases forwarded for post-mortem examination, during the period 2016- 2018, there were 39 cases (69.64%, n=56) with MCCD issued by the treating doctor. In these 39 cases, the indications / reasons given for forwarding the case for post-mortem examination were based on Section 174 (3) CrPC.

In 7 (17.95%, n=39) cases, though cause of death was given by the treating doctor, the police had forwarded the cases for post-mortem examination as it is mandatory by the law as per first three subclauses of Section 174 (3) CrPC. However, there was no discrepancy noted between the underlying COD, certified by the treating doctors and determined after post-mortem

examination. The Investigating officers have handed over 53 (48.62%, n=109) cases to the relatives, without forwarding them for post-mortem examination, based on available records, including MCCD, provisions of Section 174 CrPC and by applying their power of discretion.

Whenever the case is forwarded for post-mortem examination, it is bound to increase the stress, grief of the family members irrespective of its reason, benefits and counseling done. It is also going to require more time as compare to bodies handed over without forwarding them for post-mortem examination. In our study, after implementation of project, 53 (48.62%, n=109) cases were directly handed over to the relatives along with MCCD after taking their NOC and also giving them NOC without forwarding them for post-mortem examination. When 53 (48.62%, n=109) cases were not forwarded by police for post-mortem examination, the resources got spared, including human.

## Conclusions

There is significant decrease in total number of post-mortem examination cases. Before the project, the only reason given by police, for post-mortem examination, was to know the 'COD' i.e., cause of death. After the project, different reasons [as per Section 174 (3) CrPC] with justification are coming actually on record and in practice. Police are now using structured format for inquiry/ investigation into the cause of death i.e., inquest which includes the indications for forwarding the case for post-mortem examination as per section 174 CrPC. There is no violation of any existing provision of law during implementation of this project.

We suggest that the insurance companies and public should be made aware of the provisions of law and to accept the MCCD in medico-legal cases without insisting for post-mortem examination report as there is no law which mandates post-mortem examination for insurance claims. There is a need to review the provisions of law which are making the post-mortem examination mandatory, like first 3 subclauses of Section 174 (3) CrPC, in cases where there is no justifiable reason for post-mortem examination.

We recommend to carry out similar studies at the same centre in other cases of deaths as well, apart from burn cases, like deaths in case of road traffic accident, deaths due to poisoning on prolonged admission, etc. Similar projects can be implemented in other centres throughout the country. Further expansion of the project will require; active participation of institutional authorities, district and state level authorities, as well as proper training of police officials and medical practitioners.

**Ethical Consideration:** This study is a retrospective analysis of a project on number of cases for post-mortem examination.

**Conflict of Interest:** None to declare. The order for implementation of this project was issued by the Superintendent of Police Wardha and the outcome was analyzed by the department of Forensic Medicine, MGIMS Sewagram.

**Source of funding:** None to declare.

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### Appendix I (English)

#### Modification I: Details of death

Details of death includes the following information which the I.O. is supposed to fill

Was the deceased under treatment of any medical practitioner? Y / N

If yes, please give the following details:

Period of admission: .....

Date and time of deaths as per the treating doctor: .....

Whether MCCD has been collected from the treating doctor? Y / N

If not, mention the reason: .....

Cause of death as per the treating doctor (MCCD Form 4 / 4A): .....

Opinion of Panchas and me (I. O.)

Cause of death is: .....

OR

Cause of death is not certain: .....

### Appendix: II (English)

#### Modification II: Reasons for post-mortem examination [Section 174(3) CrPC]

Whether the body is to be sent for post-mortem examination- Yes / No, if yes, please give the reason from following provisions-

- i. the case involves suicide by a woman within SEVEN years of her marriage; or
- ii. the case relates to the death of a **woman within SEVEN years of her marriage** in any circumstances raising a **reasonable suspicion** that some **other person committed an offence** in relation to such woman; or
- iii. the case relates to the death of a **woman within SEVEN years of her marriage** and **any relative** of the woman has **made a request** in this behalf; or
- iv. there is any DOUBT REGARDING THE CAUSE OF DEATH; or
- v. the police officer **for ANY OTHER REASON** considers it expedient so to do, (please explain): .....

### Appendix III (English)

#### Modification III: NOC from relatives

##### NOC from Relatives

NOC must be taken as follows from the relatives of the deceased in cases where the body is not being sent for post-mortem examination:

To, ..... Date:.....

Mr. / Ms.....

The Investigating Officer, ..... Police Station.....

Subject: NOC for not doing the post-mortem examination.

Sir / Madam,

The cause of death of the deceased .....

Age.....Sex.....R/O.....is.....

.....as per the MCCD certified by the treating doctor. We agree upon the same cause of death and we have no objection / allegation / query regarding the same.

Hence, we kindly request you not to do the post-mortem examination.

Witness (Name and signature) ..... Name of relative:.....

1. .... Signature:.....

2. .... Relation with the

deceased.....

(Son/ Daughter/ Mother/ Father/ spouse)

### Appendix IV (English)

#### Modification IV: NOC from Police

##### NOC from Police

NOC must be given as follows to the relatives of the deceased in cases where the body is not being sent for post-mortem examination:

To, ..... Date:.....

Mr. / Ms.....

Relation with the deceased.....

Subject: NOC for not doing the post-mortem examination.

Sir / Madam,

This is the NOC given to you, on the basis of the cause of death .....

.....of the deceased .....

Age.....Sex.....R/O.....as per the MCCD certified by the treating

doctor. We, the police, witnesses and the relatives agree upon the same cause of death and we

have no objection / allegation / query regarding the same. Hence, no post-mortem examination

is requested in this case. Kindly take note of the same.

Signature: .....

Name of the I.O.: .....

B. No.: .....

Police Station: .....

## Reliability of Glasgow Coma Scale in Traumatic Brain Injury: A retrospective analysis

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### Abstract

Glasgow Coma Scale is a valuable tool in the monitoring and management of traumatic brain injury. Still the reliability of GCS is suspected. A retrospective analysis was undertaken to assess the reliability of GCS recorded in head trauma cases by comparing the initial GCS score recorded following hospitalization and last GCS documented prior to death. Hospital record of sixty cases that had been hospitalized and died of traumatic head injury during treatment was analyzed, over a period of two years. The initial GCS score at the time of admission and last GCS score recorded preceding the death of patient was studied. McNemar-Bowker test was applied for symmetry around the diagonal of the table and Wilcoxon signed-rank test was used to analyze the statistical significance between the initial and last recorded GCS scores. The change in GCS score from initial to last record examined by applying the McNemar-Bowker statistical test and found to be significant ( $p$  0.016). The distribution of median from initial to last GCS record assessed by non-parametric Wilcoxon Signed Ranks test and was found statistically significant ( $p$  0.001). To endure the reliability of GCS and to make it more efficacious, teaching and training in evaluating GCS to its users across relevant disciplines has to be imparted on regular basis. It will improve inter-rater reliability. Standard operating procedures to be formulated for applying standardized stimuli for assessing pain response.

### Keywords

GCS; Head injury; ICU; Trauma; Emergency

### Introduction

The Glasgow Coma Scale (GCS), a 15-point scale, is used as structured method in clinical settings to evaluate the depth of impaired consciousness and coma. It was developed in 1974 as a 14-point scale by Teasdale and Jennett and later on revised three years later to its current 15-point scale.<sup>1,2</sup> It has been commended by clinicians since it came into existence. Although it was primarily designed for use in head trauma cases, it is used in a variety of clinical settings for the evaluation of level of consciousness.<sup>3</sup> It assess the eye, verbal and motor responses to portrays the level of consciousness. The three components (eye, verbal and motor) can be scored individually or collectively in a sum score, ranging from 3 to 15. The score thus enables the comparison both amongst patients and of deviations in patients over a period of time that proves decisive in the management of such patients. The sum score of GCS was initially used for the research purpose, but later it was followed in clinical settings also.<sup>3,4</sup> GCS score of <8 reflected a severe head injury, GCS ranging from 9 to 12 moderately severe and GCS>12 as mild head injury.<sup>5,6</sup> A linear relationship exists between declining sum scores and rising mortality in patients with traumatic brain injury (TBI).<sup>7</sup> Out of the three components, the motor element is a strong predictor of poor outcome in

moderate/severe TBI.<sup>8</sup> Though, the GCS provides valuable information regarding the prognosis in head trauma cases and guides the management protocol in intensive care units/emergency settings, still controversy exists on its reliability.<sup>1</sup> Its reliability has been assessed in many studies by using variety of measures, but some sort of disagreement still surrounds it.<sup>9</sup>

In clinical forensic medicine practice, a forensic expert has to give opinion regarding the nature of injury whether injury in question is a grievous or endanger the life. In cases of head injury, the clinical record of the patient forms the basis of such opinion. Sometimes, it has been observed that GCS score and clinical outcome of the victim are contrary to each other. Therefore, a retrospective analysis was undertaken to assess the reliability of GCS recorded in head trauma cases by comparing the initial GCS score recorded following hospitalization and last GCS documented prior to death.

### Materials and Methods

The retrospective study was carried out in a tertiary care teaching institute. Hospital record of sixty cases of traumatic head injury that had been died of traumatic head injury during treatment and subsequently underwent postmortem examination over a period of two years was analyzed. Cases of traumatic head injury who had been admitted and treated in our institute with serial GCS documentation in their inpatient record constitutes the study group were included in the study, while the patients who died during first aid measures were excluded from the study.

The initial GCS score at the time of admission and last GCS score recorded preceding the death of patient was noted down. None other than the resident duty doctors recorded the GCS

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score. The data collected was entered in Microsoft excel sheet and statistical analysis was done. SPSS statistical software version 16.0 was applied to analyze the scientific data. McNemar-Bowker test<sup>10</sup> was applied for symmetry around the diagonal of the table and Wilcoxon signed-rank test<sup>11</sup> was used to analyze the statistical significance between the initial and last recorded GCS scores.

## Results

Out of total sixty cases, three (5%) deceased had GCS score of more than 12, 22 (36.7%) had between 8-12 and <8 score was recorded in 35 (58.3%) of cases at the time of admission, that is initial GCS score. While <8 score was recorded in 75% of cases (45/60) preceding death, means last GCS recorded. The move of GCS score from initial to last record was examined by applying the McNemar-Bowker statistical test and found to be significant ( $p < 0.05$ ) as shown in Table 1. The distribution of median from initial to last GCS record was assessed by non-parametric Wilcoxon Signed Ranks test and was found statistically significant ( $p < 0.001$ ) as depicted in Table 2.

**Table 1:** Record of Glasgow Coma Scores of the patients (GCS)

Observation time	Score						P-value
	>12		8-12		<8		
	No.	%	No.	%	No.	%	
Initial	3	5	22	36.7	35	58.3	0.016
Last	4	6.7	11	18.3	45	75	

**Table 2:** Median and Inter Quartile range (IQR) of GCS at initial and last examination

	GCS-Initial	GCS-Last	P-value
Median	5.5	5	0.001
IQR	4 to 9	3 to 7.75	

## Discussion

The recognition of the GCS is such that it has remained the most commonly accessed tool for evaluation of unconscious patients. GCS is the sequential documentation of eye, verbal and motor responses and scores during the management of patients with impaired consciousness.<sup>12</sup> With progressive monitoring, it enables rapid detection of neurological complications in patients of traumatic head injury.<sup>4</sup> It determines the evolving clinical situation of such patients and become an imperative channel for communicating on patient's condition amongst different healthcare professionals.<sup>12</sup> However, the scale was never intended to be used as a guide to outcome.<sup>13</sup>

Theoretically, reliability is the degree to which a tool is free from measurement error. Reliable scoring is essential for the practical efficacy of the GCS.<sup>14</sup> Glasgow Coma scale has various limitations.<sup>15</sup> It has an external element or inter-rater reliability, as the same subjects being evaluated by different observers, and an internal element i.e. intra-rater and test-retest reliability, which reflects the degree to which the scale produces same results over the time and on different junctures, assuming stable conditions.<sup>4,16,17</sup> Other limitations of the GCS are its inability of testing verbal component in intubated patients, incompetence to mark brainstem reflexes and breathing pattern, and failure to notice subtle change in neurological examination.<sup>18</sup>

Reith et al. in their systematic review on the reliability of the Glasgow Coma Scale identified 52 relevant studies that depicts significant heterogeneity in the type of reliability estimates used, patients studied, setting and characteristics of observers.<sup>1</sup> They observed that only 13% of studies were of good quality. Inconsistency in reported reliability estimates were found in numerous studies. From a clinical viewpoint, focus on training/education and standardization of assessment is required. Teaching and training in evaluating GCS to all new/inexperienced users across relevant disciplines has to be imparted. Besides that, measures for regular education and encouragement of competence for experienced users to be undertaken periodically. Rather than using of the sum score, reporting and documentation of each of the three components separately was recommended. Rowley and Fielding observed that users inexperience is associated with a high rate of errors while scoring using Glasgow Coma Scale. The reliability of the GCS surges with the experience of its users.<sup>18</sup>

In present study, the GCS scores was evaluated and documented by none other than the resident duty doctors. The move of GCS score from initial to last record was found to be significant. The distribution of median from initial to last GCS record was also statistically significant. The inter-rater reliability of GCS as an outcome predictor was observed as statistically significant in the present study, because the resident Doctors who were well familiar with GCS score and method to evaluate the GCS score recorded the GCS. Lower the cumulative GCS score, higher the mortality. Tien et al. also observed that a significant correlation exists between a low GCS and poor prognosis and higher mortality, predominantly when pupils are bilaterally fixed and dilated.<sup>19</sup>

To counter the limitations and deficiencies of GCS, several ICU scoring systems have been developed. The Full Outline of Unresponsiveness (FOUR) score, a newer coma scale in the appendix, was developed in the Mayo Clinic in Rochester, Minnesota. It evaluates 4 components: eye, motor responses, brainstem reflexes, and respiration.<sup>15,20</sup> It is centered on the bare minimum of tests which are essential for evaluating a patient with altered consciousness. It also incorporates vital information like assessment of brainstem reflexes and the

presence of abnormal breath rhythms and a respiratory drive, which is not assessed by the GCS.<sup>20,21</sup>

Even after advent of other parameters, the GCS is most widely used scale by the clinicians till date for assessment of traumatic brain injury because it is easy to use and reproducible.<sup>22</sup> Of the three components of GCS, the motor scale is the most important. Confusion and controversy persist concerning the best location and approach for applying a painful stimulus.<sup>4</sup> To assess unresponsive patients, standardized stimuli to be applied and uniform strategies be formulated to deal with unmeasured features.<sup>1</sup>

One of the limitations of current study is that the inter-rater variability of GCS scoring cannot be negated. Although, the resident Doctors in the current study recorded the GCS scores, but it was not observed by a single doctor throughout the course of treatment of victim.

## Conclusions

The Glasgow Coma Scale is an irreplaceable tool for evaluation of traumatic brain injury. Lower the score, greater the mortality rate. It is easy to use and reproduce. However, to endure its reliability and make it more efficacious, teaching and training in evaluating GCS to its users across relevant disciplines has to be imparted on regular basis. It will improve inter-rater reliability. Standard operating procedures to be formulated for applying standardized stimuli for assessing pain response.

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## Pattern and distribution of skeletal injuries in victims of fatal road traffic accidents

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### Abstract

Globally, road traffic accidents are increasing at an alarming rate, with victims usually sustaining multiple injuries, with skeletal injuries being one of the commonest injuries with increased mortality rates secondary to vital organ injuries and massive haemorrhage. The present study assesses the pattern and distribution of skeletal injuries in victims of fatal road traffic accidents and its relationship with cause of death. We found that majority (51%) of the victims were aged between 21-40 years with male preponderance (83%). Motorcyclists were the most common victims (53%), followed by pedestrians (18%). Most common sites of fractures were of the skull (74%), ribs (43%) and lower limb bones (18%). Forty percent of cases succumbed to injuries within 24 hours of accident. Most common cause of death was head injury (71%), followed by haemorrhagic shock (18%). Skull fracture was present in 95.78% of victims who died of head injury.

### Keywords

Road Traffic Accidents; Motorcyclists; Head Injury; Fractures

### Introduction

Accident is an unpremeditated event, resulting in a recognizable damage.<sup>1</sup> Accidents occur in all forms of transportation, with road traffic accidents (RTA) being most common worldwide. As per the World Health Organization, RTA account for almost 1.3 million deaths and 20-50 million non-fatal injuries per year globally. By the year 2030, it has been predicted to be the fifth leading cause of death, resulting in an estimated 2.4 million fatalities per year.<sup>2</sup> Tremendous increase in the number of fast moving vehicles, inexperienced drivers, influence of alcohol, ignorance or violation of traffic rules, and poor designing and condition of roads has collectively led to increase in deaths due to traffic accidents at an alarming rate. The present study was undertaken to know the pattern of skeletal injuries in relation to various modes of travel and distribution of fractures in victims of fatal RTA and their relation to cause of death and duration of survival.

### Materials and Methods

All victims of RTA who presented to SDM College of Medical Sciences and Hospital, Dharwad for treatment but subsequently died during treatment, and those declared as brought dead on arrival at the emergency room, between 1<sup>st</sup> January, 2013 to 30<sup>th</sup> June, 2014 were subjected to post-mortem examination and included in the study. Information of the deceased regarding

age, gender, and characteristics reflecting circumstances of accident like mode of travel, type of offending vehicle, and place of accident was gathered from all possible sources like history from key informants, medical and police records, and cause of death was ascertained. Data from the proforma was compiled, tabulated, and analysed by descriptive statistics by calculating means, percentages and proportions. Data analysis was done using Microsoft excel worksheet 2010. Ethical clearance was obtained from the Institutional Ethical Committee.

### Results

Of 187 autopsies conducted during the study period, majority of the cases were RTA (N=100, 53.48%), followed by poisoning (N=43, 22.99%) as shown in Table 1. One-half of the victims (51%) belonged to the age group of 21-40 years, with male preponderance (83%) as shown in Table 2. Mean  $\pm$  S.D. age among males, females and the total sample was  $36.08 \pm 15.77$ ,  $40.47 \pm 21.35$ , and  $36.83 \pm 16.80$  years respectively. Most of the cases occurred on National highways (38%) and city roads (33%). One-half of victims of fatal RTA were motorcyclists and pillion riders (53%), while pedestrians accounted for 18%. Majority of the victims had an alleged history of accidental fall from moving vehicle (30%), followed by RTA in collision with offending vehicles such as Heavy motor vehicle (23%), motorcycle (13%), Light motor vehicle (12%) and Medium motor vehicle (6%). Nine cases (9%) had collision with stationary objects like pole, tree, wall, etc. The offending vehicle was not known in 7% of cases.

Multiple skeletal injuries occurred in all victims, while most common site of fractures included the skull (74%), ribs (43%) and lower limb bones (30%) as shown in Table 3. Amongst 74 cases with skull fractures, majority had fractures of the vault

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and/or base of the skull (93.24%), followed by combined vault and basal skull fractures (51.35%). Of 55 cases with vault fractures, most common type was linear or fissure fracture (N=35, 63.64%), followed by comminuted fracture (N=19, 34.55%) and the most common affected site was temporal bone (N= 31, 56.36%), followed by parietal bone (N= 27, 49.09%).

Most common skeletal injury found in pedestrians (N=18) was skull fractures (72.22%), irrespective of the type of offending vehicles. Among pedal cyclists (N=3), skull fractures, rib and hand bone fractures were noted. Among motorcyclists (N=53), skull fractures were the commonest finding observed (86.79%). In those motorcyclists who collided with a Heavy Motor Vehicle (21%), multiple fractures were a common finding. In drivers of four-wheelers (n=13), fracture of ribs (53.84%) and skull (46.15%) were common followed by long bone fractures. Among front seat passengers, fracture of skull and ribs were commonly observed. Among rear seat passengers, fracture of skull and forearm bones was noted.

Forty percent of the cases succumbed to injuries within 24 hours following RTA, of which two-thirds occurred within crucial time of first six hours (Table 4). Head injury was the commonest cause of death in all categories of victims (70%), while in drivers of motor vehicles haemorrhagic shock accounted for most of the deaths (53.84%). Skull fracture associated with intracranial haemorrhages was observed in 95% of the cases with head injury, while only five percent of the victims had intracranial haemorrhage without skull fracture (Table 4). Haemorrhagic shock accounted for 18% of the cases, of which 45% had multiple limb fractures, and 55% cases had visceral injuries associated with rib fractures. Nine percent of the cases, despite treatment died after two weeks due to medical complications like septicaemia and bronchopneumonia, mostly associated with rib fractures and associated complications (Table 4).

**Table 1:** Distribution of cases

Autopsy case	N (%)
RTA with skeletal injury	100 (53.48)
Poisoning	43 (22.99)
Fall from height	17 (9.09)
Natural causes	12 (6.42)
Hanging	4 (2.13)
Drowning	3 (1.61)
Assault	3 (1.61)
Others (electrocution, railway and industrial accidents)	5 (2.67)
Total	187 (100)

**Table 2:** Age and sex distribution of victims of fatal RTA

Age (years)	Male (n = 83)	Female (n = 17)	Total (N = 100)
≤10	1	3	4
11-20	8	0	8
21-30	32	1	33
31-40	15	3	18
41-50	9	5	14
51-60	12	3	15
≥ 61	6	2	8

**Table 3:** Distribution of skeletal injuries in victims of fatal RTA

Type of bone involved	N	
Skull (n = 74)	Vault alone	17
	Base alone	14
	Both vault and base	38
	Facial bones alone	5
	Vault and/or base	69
	Facial bones with vault and/or base	19
Vertebrae (n = 8)	Cervical	3
	Thoracic	4
	Lumbar	2
Clavicle	9	
Sternum	6	
Ribs	43	
Humerus	9	
Radius	7	
Ulna	9	
Wrist & Hand bones	5	
Pelvis	9	
Femur	12	
Tibia	16	
Fibula	13	
Foot bones	4	

**Table 4:** Relation between cause of death and period of survival

Period of Survival	N	Head injury (N=71)	Hemorrhagic shock (N=18)	Septicemia (N=7)	Broncho-pneumonia (N=4)
<6 hours	27	17	10	0	0
6-24 hours	13	9	4	0	0
>1-3 days	10	8	2	0	0
>3-7 days	27	23	2	1	1
>1-2 weeks	14	11	0	2	1
>2-4 weeks	9	3	0	4	2

## Discussion

In the present study, deaths due to RTA accounted for 53.84% of the total medico-legal autopsies conducted at the place of study. This study is consistent with many other studies from Karnataka and North India.<sup>3,4</sup> Some studies have reported lower prevalence of deaths due to RTA,<sup>5-7</sup> which could be due to difference in study population, planning of cities, driver behaviour, strict enforcement of traffic rules, local terrains or condition of roads. In our study, all victims of fatal RTA presented with skeletal injuries, with more than one-half of victims being young adults aged between 21-40 years, with male preponderance. These findings are in accordance with many other similar studies.<sup>8,9</sup> This finding may be due to work transit and increased risk-taking behaviour in young and middle-aged men. Majority of the fatal RTA occurring on National Highways could be attributed to the high speed of travelling vehicles, unscientific laying of speed-breakers and diversions, thus leading to loss of control and increase in the accidents.

In current study, most victims were motorcyclists, probably due to the fact that two-wheeler vehicles are easy to ply on roads, are more economical, fuel efficient, affordable and thus constitute majority of the traffic vehicular load when compared to other vehicles. Fatalities among motorcyclists could also be due to higher speed, reckless driving and lesser stability when compared to four-wheeler vehicles.<sup>10</sup> These findings are consistent with most other Indian studies.<sup>9,11</sup> However some studies have reported pedestrians and passengers of light motor vehicle to be the commonly affected victims.<sup>5,12</sup> This variation could be due to difference in the prevalence of transport system which is often influenced by the working pattern of that demographic area.

Majority of the victims, mostly motorcyclists had an accidental fall from a moving vehicle. This may be due to higher speeds, loss of control, unscientific positioning of speed-breakers, poor designing and asphaltting of roads, poor maintenance of roads, pot-holes, resulting in such accidents. Skull, ribs and long bone fractures being most common sites of skeletal injuries in

victims of fatal RTA, either due to primary or secondary impact, signifies the utmost need for proper usage of protective aids, like helmets (for both riders and pillion-riders), seat-belts and air-bags, while driving vehicles.

Predominance of skull fractures among pedestrians, pedal cyclists and motorcyclists may occur as a result of secondary impact and secondary injuries invariably involving head, irrespective of the site of primary impact. Among drivers of motor vehicles, rib fractures were the commonest skeletal injuries noticed (53.84%), followed by skull fractures (46.15%). These victims had haemorrhagic shock as the commonest cause of death, due to rib fractures and associated visceral injury. This may be due to the steering wheel, which may provide some protection to drivers of motor vehicles against skull fractures from windscreen collisions or from being ejected out of vehicle, although it usually injures chest (ribs), in the absence of air-bags. In contrast, front seat passengers are at higher risk of skull fractures due to impact with windscreen or following ejection from moving vehicle, albeit absence of steering wheel, especially when not using seat-belts, or absence or malfunctioning of air-bags. Two-thirds of those with skull fractures were of linear pattern (63.64%) in comparison to one-third having comminuted (34.55%). This finding may be due to, the head of victim forcibly striking a broad resisting surface like roads. In our study, temporal bone being the thinnest bone was most commonly affected (56.36%), followed by parietal bone (49.09).

Of the victims who survived for a period of less than 24 hours, more than two-thirds succumbed within first six hours following RTA. These findings imply the significance of 'golden period' when the victim can be resuscitated and affordable early medical or surgical interventions be provided, along with the need to establish sophisticated trauma centres at accessible distances. Also, most victims who died due to head injury survived for a period of seven days, possibly due to early and prompt neurosurgical decompression, but succumbed to delayed complications like septicaemia and bronchopneumonia.

## Conclusions

Fatal RTA are associated with higher propensity in the younger age group, especially males, with motorcyclists and pedestrians being the commonest victims. Multiple skeletal injuries should raise high index of suspicion for higher mortality, especially when fractures of the skull, ribs and lower limb bones are noticed, thus necessitating the need for early resuscitation and interventions. Higher mortality in more than half of the RTA cases within first six hours calls for the urgent affordable and accessible emergency health care needs during this 'golden' period, especially by means of sophisticated trauma centres with efficient manpower resources with early trauma care.

In addition, recently enforced new Motor Vehicle (Amendment) Act 2019 with more stringent penalizing measures like compulsory helmets for motorcyclists and seat belts for motor vehicle occupants, following lane disciplines, enforcing traffic rules by law enforcement authorities, and weaning of aged vehicles appears prudent.

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## Epidemiological profile of fatal burn cases in tertiary care centre of Lucknow: An observational study

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### Abstract

Burn is one of the most common injuries which has been recognized as public health problem. It affects nearly every population and every geographical zone in the world and have always been considered as one of the most destructive injuries, causing not only morbidity and mortality but also major economic and psychological impacts. This study intends to explore the medicolegal aspects and recent epidemiological trends of burn cases. This is an autopsy based cross sectional observational study from a period of August 2015- July 2016 and was carried out in the department of Forensic Medicine and Toxicology, King George's Medical University, Lucknow, Uttar Pradesh. Cases were thoroughly studied using specially designed proforma that include demographic profile of deceased, history from relatives, police and hospital records and autopsy findings. A total of 550 burn cases were studied for which significant information regarding epidemiological and medicolegal aspects have been obtained. Out of 550 cases, majority were females 70.18%. Male: Female ratio was 1:2.35. The age of the victims ranged from age 7 months to 84 years and mean age was 28.98±11.65 years. Most common affected age group was 21-30 years (47.45%). Majority of cases were married. A statistically significant ( $p=0.019$ ) higher proportion of married cases were found among female. Majority of the cases were housewives (60.97%), followed by students (15.80%), farmers (11.52%), businessmen (4.83%) and laborers (4.46%). Majority of the cases, 82.55% occurred at home and only 2.91% at workplaces, rest 14.55% cases occurred elsewhere. The majority of the cases occurred in Summer and Winters seasons (38.91% and 37.91%), while least number of cases were seen during Monsoon season (6.36%). Majority of burn injuries were found to occur between 2:00 pm -10:00 pm. Flame was the most common type of causative agent in males as well as in females, however difference in causative agent of burn injuries of female and male cases was found to be statistically significant ( $p<0.001$ ). Most common percentage of TBSA involved was >80% (36.73%), while in 2.18% cases %TBSA was 1-20%. Commonest manner of death among burn injury cases was found to be accidental. And also, among accidental cases, proportion of males was higher than females, while proportion of females was higher in homicidal and suicidal cases.

This study highlights the parameters that should make the clinician reassess the course of treatment, warning that the patient might be critically near death. For example, the probability of sepsis increases with prolonged ICU stay. Patient's age and % TBSA affect the mortality of post trauma victim.

### Keywords

Burn; Sepsis; TBSA; Autopsy

### Introduction

One of the landmark catalysts in the development of the human species was achieved when man not only acquired the ability to harness fire but also control and manipulate it. Fire gave man crucial tools to aid survival, improving quality of life as well as lengthening the average lifespan. But it was also a double-edged sword when not controlled, it can cause great destruction and injury. Burns being a highly preventable injury is still an

undeniably serious public health hazard across the world. Following traffic accidents, falls and interpersonal violence, burns are the most common injuries worldwide.<sup>1</sup> As stated by WHO the three following regions having the highest prevalence rates are Western Pacific Region, Eastern Mediterranean Region and Southeast Asia Region.<sup>1</sup> Low and middle income countries have a greater burden of fire-related burns than high income countries.

In India, with a population of over 1 billion, there are 7,00,000 to 8,00,000 burn admissions annually<sup>2-3</sup> and about 10,000 succumb to thermal injuries.<sup>4</sup> Uttar Pradesh is India's fourth largest state and most populous, with Lucknow being the biggest city and capital of Uttar Pradesh, having a population density of around 1815 inhabitants per sq Kilometer. The high incidence of burns cases makes it an endemic health hazard. Medico legally deaths due to burn is very important as it is one

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of the most common causes of unnatural deaths in India. Often the manner of burns is unfathomable. The motives behind this action may be personal, domestic, occupational or social tragedy, and dowry deaths. Autopsy has previously been shown to be a useful retrospective diagnostic tool.

Analysis of the various epidemiological and medico-legal aspects in the community help to plan the preventive programme for reducing the incidence of fatal burns. The aim of the study was to study the medicolegal aspects and recent epidemiological trends of burn cases brought to mortuary KGMU Lucknow.

### Materials and Methods

The present study is an autopsy based cross sectional observational study from a period of August 2015- July 2016 and was carried out in the department of Forensic Medicine and Toxicology, King George’s Medical University, Lucknow, Uttar Pradesh. Cases were thoroughly studied using specially designed proforma that include demographic profile of deceased, history from relatives, police and hospital records and autopsy findings.

### Results

A total of 550 burn cases were studied for which significant information regarding epidemiological and medicolegal aspects have been obtained. Out of 550 cases, majority were females 70.18%. Male: Female ratio was 1:2.35. The age of the victims ranged from age 7 months to 84 years and Mean age was 28.98±11.65 years. Most common affected age group was 21-30 years (47.45%) as shown in Table 1.

Table 1: Age wise sex distribution of the study sample

Age (years)	Total (N=550)	Females (N=386)		Males (N=162)	
		N	%	N	%
≤ 10	14	6	42.86	8	57.14
11-20	93	67	72.04	26	27.96
21-30	261	190	72.80	71	27.20
31-40	113	81	71.68	32	28.32
41-50	44	26	59.09	18	40.91
51-60	16	10	62.50	6	37.50
61-70	6	4	66.67	2	33.33
71-80	2	2	100.00	0	0.00
>80	1	0	0.00	1	100.00
	550	386	70.18	164	29.82

χ²=12.400; P-value=0.134

Most of the victims were married. A statistically significant (p=0.019) higher proportion of married cases were found among female (Table. 2).

Table 2: Association of sex and marital status

Marital Status	Total (N=548)	Females (N=386)		Males (N=162)	
		N	%	N	%
Married	439	320	82.90	119	73.46
Unmarried	103	61	15.80	42	25.93
Widow/Widower	6	5	1.30	1	0.62

χ²=7.971; P-value=0.019

2 cases were unknown and their residential status could not be ascertained. Out of the remaining 548 cases 69.34% belonged to rural areas, 8.21% to semi-urban and rest 22.45% belonged to urban areas. Majority of the cases were housewives (60.97%), followed by students (15.80%), farmers (11.52%), businessmen (4.83%) and laborers (4.46%). The majority of the cases, 82.55% occurred at home and only 2.91% at workplaces, rest 14.55% cases occurred elsewhere. Most of cases occurred in Summer and Winters seasons (38.91%and37.91%), while least number of cases was seen during Monsoon season (6.36%). Majority of burn injuries were found to occur between 2:00 pm -10:00 pm (Table 3).

Table 3: Time of occurrence of burn injury in females and males

Time of burn injury	Total (N=548)	Females (N=386)		Males (N=162)	
		N	%	N	%
6 AM to 2 PM	175	117	30.31	58	35.80
2 PM to 1010 PM	311	224	58.03	87	53.70
10 PM onwards	62	45	11.66	17	10.49

χ²=1.591; P-value=0.451

Table 4: Causative agent of burns in females and males

Causative agent	Total (N=550)	Females (N=386)		Males (N=162)	
		N	%	N	%
Chemical	3	0	0.00	3	1.83
Flame	513	383	99.22	130	79.27
Electrical	29	1	0.26	28	17.07
Hot liquid	5	2	0.52	3	1.83

χ²=75.865; P-value<0.001

Table 5: Manner of burn injury in females and males

Manner	Total (N=550)	Females (N=386)		Males (N=162)	
		N	%	N	%
Accidental	278	147	38.08	131	79.88
Homicidal	97	87	22.54	10	6.10
Suicidal	175	152	39.38	23	14.02

χ²=80.672; P-value<0.001

Flame was the most common type of causative agent in males as well as in females, however difference in causative agent of burn injuries of female and male cases was found to be statistically significant ( $p < 0.001$ ). (Table 4) Most common percentage of TBSA involved was  $>80\%$  (36.73%), while in 2.18% cases, % of TBSA was 1-20%. Most common manner of death among burn injury cases was found to be accidental. And also, among accidental cases, proportion of males was higher than females, while proportion of females was higher in homicidal and suicidal cases. Difference in manner of burn injury between male and female cases was found to be statistically significant ( $p < 0.001$ ) as shown in Table 5. % TBSA affected in homicidal cases of burn injury was found to be statistically higher than those with accidental and suicidal injury. Burn percentage of TBSA in patients who survived for higher duration was statistically found to be significantly lower ( $p < 0.001$ ) than that of who survived for lesser duration (Table 6). Commonest cause of death was found to be Sepsis (48.18%), followed by Neurogenic shock (29.45%), Hypovolemic shock (14.00%), Asphyxia (3.09%), Multi-organ failure (2.73%) Cardio-respiratory failure (2.18%) and Other causes (0.36%).

**Table 6:** Association of duration of hospital stay and burn percentage of Total Body Surface Area (TBSA)

Duration of hospital stay	N	Minimum	Maximum	Median	Mean	SD
0-6 hours	154	1	100	90	78.88	24.47
7-12 hours	49	10	98	90	83.51	18.23
13-18 hours	5	65	98	90	84.60	14.08
2-3 days	64	40	98	80	76.36	15.45
4-7 days	185	30	95	70	67.83	14.66
8-14 days	71	25	85	60	56.76	10.25
>14 days	22	30	60	50	46.59	9.05
Total	550	1	100	70	71.19	20.08

SD – Standard Deviation

F=25.956;  $p < 0.001$

## Discussion

Out of total 5043 autopsies done in a span of one-year (August 2015 to July 2016) burn constitutes 10.95% (550 cases) of the total. Burn ranks second amongst most common cause of death next to road traffic accidents. Despite being highly preventable it constitutes a serious public menace. This is similar to the result obtained from the study done by Gupta et al. (10.79%).<sup>5-6</sup>

High incidence of cases was observed in the most reproductive age group (21-30 years), with a female preponderance and male: female ratio in present study was found to be 1:2.35. This study was consistent with the studies of Gupta et al.<sup>5-6</sup>, Batra et

al.<sup>7</sup>, Shinde et al.<sup>8</sup>, Singh D et al.<sup>9</sup> and Malla et al.<sup>10</sup> Similarly, Agha et al.<sup>11</sup> found twice as many women burn victims than men, between the age of 16 and 40 years. In study of Zanjad et al.<sup>12</sup>, male to female ratio was 1:2.5 which is similar to the findings of the present study. The reason behind this, seems to be the fact that a majority of the victims were married females who were more prone to kitchen-related incidents at home, other factors were interpersonal violence, domestic violence, and less coping skills among them, also made them prone for suicides etc. On the other hand, male predominance was observed in developed nations like, South Korea, Japan and China.<sup>13-15</sup> This may be explained by the fact that because of rapid industrialization in these countries, male become more susceptible of fatal burns at work place as compared to females. Similar results were seen in other studies in India as done by Ambade et al.,<sup>16</sup> Singh et al.,<sup>9</sup> and Ghuliani et al.<sup>17</sup> The reason behind it seems to be the increasing stress among married couples in day to day activities like cooking, job and care of children place them at high risk of frequent burn accidents.

The studies done by Zanjad et al.<sup>12</sup>, Batra et al.<sup>7</sup>, Shinde et al.,<sup>8</sup> observed that most of burn death occurred in rural areas, which was similar to our study on the other hand Chawla et al.<sup>18</sup> reported contrary to our result, with more burn victims from urban areas (72%) than rural areas (28%). The reasons for more incidence of death due to burn in rural population are improper health services, non-functional burn care units in rural areas and also lack of proper transportation facility to higher centers, leading to travel delay and hence high mortality rate. The findings are consistent with those of Kumar et al.<sup>19</sup> Our study population comprises more of Hindu women which is consistent finding with that of Rai et al.<sup>20</sup> but this is in contrast to the finding of Devdas et al.<sup>21</sup> who saw more suicide in the Christian community in Bangalore city. This is most probably due to the fact that Lucknow is Hindu dominated city, where approximately 71% population is Hindu and 26% people are Muslims, while remaining population comprises other communities and also due to involvement of the females in the activities related to cooking. The present study is consistent with many Indian studies like those of Gupta et al.<sup>5</sup>

Our findings were consistent with that Gupta et al.<sup>5</sup> and another study by Shinde et al.<sup>8</sup> showing that a greater number of female victims sustain burn during night hours. One third injuries have occurred between 4pm to 8pm in study of Gowri et al.<sup>22</sup> and were similar to other studies conducted in India because this is the usual period during when evening meals are cooked and equipment or light are also used. In the studies of Dr. Gupta et al.<sup>5</sup>, Gowri et al.<sup>22</sup> and Shinde et al.<sup>8</sup> kitchens were found to be the major culprit site of the incidence of the burns and these findings are consistent with our findings. Low socio-economic status, large families, small living space, stove and chula at floor level collectively increase the risks for these incidences.

Due to the cost factor, female predominance in open areas, having unguarded cooking fire is very common in the low socio economic agricultural and rural families of Indian society. A recent study by Ahuja et al.<sup>2</sup>, documented that economic uplift and shift from kerosene to safer LPG stoves has brought down annual burn admission by 43% in a major burn unit of Delhi. The most common agent of fire in our study was found to be kerosene, which was similar to other studies done by Agarwal et al.<sup>23</sup>, Rao et al.<sup>24</sup> and Singh et al.<sup>25</sup>, who also reported kerosene burner as the commonest causative agent for causing burn.

Kumar et al.<sup>19</sup> reported wood burner (40%), kerosene burner (34.4%) and kerosene lamp (20%) as the common causative agents for accidental burning and pouring of kerosene over body for suicidal and homicidal burning. Shinde et al.<sup>8</sup>, Kumar V et al.<sup>19</sup> observed that 2/3<sup>rd</sup> of the suicidal burns were associated with kerosene and purposeful ignition with kerosene. Malla et al.<sup>10</sup> reported kangari (60%) and kerosene stove (30%) as the commonest causative agents of burns in Kashmir. Thus the findings are more or less similar to other studies in India but there is a sharp contrast to the studies carried out in western countries where smoking, house fire, solvents and automobiles were reported to be the main cause of burns by Parks et al.<sup>26</sup> and Macarthur et al.<sup>27</sup> Pegg et al.<sup>28</sup> at Brisbane and Queensland reported that flame burns (56%) are the commonest cause of burning followed by scalds (26%). In Singapore, Angola, Ivory Coast and Ferdon, scalds were reported to be the major cause of burning Vilasco et al.<sup>29</sup>, Adoma et al.<sup>30</sup>, and Song C et al.<sup>31</sup>

In study by Zanjad et al.<sup>12</sup> revealed that in 75.1 % cases of burn extend more than 60% of TBSA. This finding is consistent with our study. It indicates that burns extending more than 60% of TBSA are usually fatal and mortality is higher in such cases though better treatment and care were provided to the patient. In our studies septicemia was observed to be major cause of death among the all burn deaths which was in accordance to other studies by Gupta et al.<sup>5</sup> Kumar et al.<sup>19</sup> and Arora et al.<sup>32</sup> noticed in their study that shock was the main cause of death and similar findings were observed by Agha et al.<sup>11</sup> These findings are in contrast to those of our study.

The study of Zanjad et al.<sup>12</sup> revealed that most of the patients died within one week of incidence and septicemia was most common cause of death. This finding is similar to studies of Gupta et al.<sup>6</sup> Infection, especially hospital acquired, involving large burnt body surface area are difficult to control in peripheral hospitals, which leads to most of the septicemic deaths. Our study has findings consistent with other studies done by Zanjad et al.<sup>12</sup>, Gupta et al.<sup>6</sup>, Batra et al.<sup>7</sup>, Ambade et al.<sup>16</sup>, in which accidental deaths is more common. In contrast to our study is Sen and Banerjee<sup>33</sup> who reported that 21 % of burn related deaths among women are due to suicide. The probable cause of more accidental deaths in our study is due to the more usage of outdated and poorly designed cooking apparatuses

which are still more prevalent in the area.

Kumar et al.<sup>19</sup> observed in his study that 70 % of these women died within 24 hours mostly from hypovolemic shock. Another study by Zanjad et al.<sup>12</sup> found that 14% cases died within 24 hours of the incidence, another 51.5% cases expired within 1 week and 34.4% person died after 1 week thus labeling septicemia as the commonest cause of death. Lal et al.<sup>34</sup> reported that mean duration of hospital stay was 8.37 days which range from 15 min to 182 days. The majority of deaths (68%) occurred within a week of the incident out of which 39.76 % died within 24 hours. Hospital stay was found to be inversely proportional to the body surface area burned.

## Conclusions

This study is an epidemiological and medicolegal study of burn death cases in Lucknow region provides a detailed overview of fatal burns. Housewives of rural areas, between age group of 21-30 years are seen to be most commonly affected, accidentally by flame burns, at home, usually in summer season and between 2:00 pm to 10:00 pm.

Prolonged survival is seen in cases having less travel time and low TBSA. Sepsis is found to be most common cause of the death in these burn victims. The results highlight parameters that should make the clinician reassess the course of treatment, warning that the patient might be critically near death. For example, the probability of sepsis and continuum to MOF seems to increase with prolonged ICU stay. Patient's age and % TBSA affect the mortality of post trauma victim.

In recent years high income countries have curtailed burn deaths to a large extent as they strengthened both preventive strategies as well as care of burn patients, which is incompletely applied in middle- and low-income countries which makes burn still a serious health hazard. Burn prevention strategies should target not only on the treatment but also on prevention modalities. It should target both the victim and the persons who are involved in burn management. Awareness programmes should be developed in which people should be educated about safety measures to be taken while cooking, promotion of safer cooking stoves and fuel, and adopting a safer and fire proof kitchen design. Adequate training of persons involved in first aid management regarding burn prevention. Improving transport facility in primary centres for early transfer of serious cases. Encourage development of proper burn-care units at primary health care centres.

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## Pattern of substance or drug abuse in cases reported by chemical examiner laboratory, Punjab, India

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### Abstract

Punjab in the northern part of India has been facing a drug or substance abuse (mainly of heroin, commonly known as chitta in Punjab) in recent years, resulting in considerable harm both to the individual and to the society. Drug abuse refers to the inappropriate (e.g., using chemicals that are never intended to be put into the body like glue sniffing), usually excessive and self-administration of a drug, any other chemical or illegal substance to affect the mind and body for a non-medical purpose. The geographical location of Punjab also contributes to the increasing problem of drug abuse. Drug abuse is also associated with crime. The analysis of available data was conducted from January to September 2018. During this period, 82 viscera cases were received by Chemical Examiner Laboratory (CEL) with a history of suspected drug abuse/drug overdose. After analysis by seven analysts, morphine, a metabolite of diacetylmorphine (the active ingredient of heroin), was found to be the most common drug. These statistics can be helpful for the government and various public health agencies to identify emerging trends of drug abuse in the state so that they can better target prevention measures.

### Keywords

Chemical Examiner Laboratory; Punjab; Drug abuse; Viscera; Heroin

### Introduction

India is a vast country with land borders and a sea coastline extending over several kilometers. It is estimated that, in India, by the time most boys reach the ninth grade, about 50 percent of them have tried at least one of the substances of abuse.<sup>1</sup> In recent years, there have been many anecdotal reports suggesting a significant problem of drug dependence in Punjab.<sup>2</sup> It is also evident that most of the drug-dependent people use opioid group of drugs such as opium, doda, bhukki, heroin, pharmaceutical opioids etc.<sup>3</sup> A study was commissioned by the Ministry of Social Justice and Empowerment in between February and April 2015 and the data was collected from a total of 3620 opioid-dependent individuals across the ten districts of Punjab namely Bathinda, Ferozepur, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Moga, Patiala, Sangrur, Tarn-Taran and according to this data most common opioid drug used in Punjab was heroin (reported by 53%).<sup>4</sup> Gul and Sharma<sup>5</sup> in their cross-sectional hospital-based study in Jalandhar (Punjab) in 2016 on 300 patients reported that opioids were the most frequently abused substances seen in 179 patients followed by alcohol and cannabinoids. In another survey by Kaur A et al<sup>6</sup> on 200 selected drug users at Faridkot medical college and hospital

during 2015-16, it was reported that 54.5% of subjects were using opioids (51% heroin, 2.5% poast and 1% morphine) followed by cigarettes, tobacco, tramadol, alcohol, and cannabis. In a study by Singh et al<sup>7</sup> in a de-addiction center of Amritsar, Punjab, 10,568 patients were screened for urine toxicology, and 9815 patients were found positive for morphine. Sharma B et al<sup>8</sup> conducted a cross-sectional study on 400 adolescents and young adults (11-35 years) from 15 villages of Jalandhar district of Punjab and reported that the most common substance abused was alcohol followed by tobacco, heroin, bhukki, and cannabis.

Heroin is a costly drug, its increasing use has also resulted in the rise of economic crimes such as snatching, robbery and theft.<sup>9</sup> Heroin is sold illegally on the street under the names smack, brown sugar, junk, dope etc.<sup>10</sup> Street heroin is often contaminated,<sup>11,12</sup> and drug addicts can never determine its purity and potency. Heroin can be utilized in almost every conceivable manner. It is commonly sniffed (snorted in), smoked or injected.<sup>11</sup>

The proper assessment of the current trends and pattern of opioid abuse can be helpful in the more effective intervention of this menace.<sup>13</sup> Thus, the objective of the present study was to assess the pattern of drugs reported in the suspected drug abuse cases received by CEL, Punjab, India.

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### Materials and Methods

The CEL to Govt. Punjab is the only government laboratory in the state of Punjab covering all districts where viscera for chemical analysis are received from police officials. An analysis of available data from January to September, 2018 was

conducted by the analysts. During this period, 82 viscera cases were received by CEL with a history of suspected drug abuse/drug overdose for analysis. In addition to viscera, non-biological exhibits e.g., syringes with needles, spoons, utensils, silver foil, tablets, etc. were also recovered by police officials in some cases of suspected drug abuse/drug overdose and were submitted to CEL for analysis. These cases were analyzed by seven analysts in CEL.

Viscera cases received without any history of suspected drug abuse/drug overdose during the period of January to September 2018 by CEL were excluded. Viscera cases received with a history of alcohol intoxication during this period were also excluded.

## Results

Morphine, a metabolite of diacetylmorphine (the active ingredient of heroin), was found to be the most common drug in this study. Morphine was found to be positive in 36 cases, while in three cases, morphine was found to be positive in combination with other drugs (tramadol and codeine). No common poisons (including substances of abuse) was detected in 32 cases. Aluminum phosphide (AIP), organophosphorus compounds (OP), organochlorine compounds (OC) were found to be positive in 11 cases (Table 1).

**Table 1:** Poison/drugs reported in cases analysed during the study period

Substance	Morphine	AIP	OP	OC	NP*	Morphine+ Tramadol	Morphine+ Codeine
Cases	36	04	04	03	32	02	01

\*NP: No common poison including substances of abuse

Out of 82 individuals who died with a suspected drug overdose, 73 individuals were in the age group of 18-35 years (89.02%), seven individuals were more than 35 years of age (8.54%), and age of two individuals was not confirmed (Table 2).

**Table 2:** Age of deceased who died of suspected drug overdose during the study period

Age range	N
18-20	05
21-25	41
26-30	21
31-35	06
36-40	04
41-45	02
46-50	01
Age not confirmed	02

District wise list of cases received is given in Table 3. Out of 39 cases in which morphine was found to be positive, in 18 cases, no morphine was detected in the stomach/small intestine and large intestine while detected in other exhibits like liver/spleen/kidney/lungs/heart and in blood. In 23 cases, various non-biological exhibits in addition to viscera were also submitted by police officials in CEL for analysis. Out of these 23 cases, morphine was found to be positive in visceral exhibits of 12 cases, and diacetylmorphine was found to be positive in non-biological exhibits (mainly syringe with a needle) connected with these viscera cases. No common poison (including substances of abuse) was detected in visceral exhibits of six cases, while morphine and diacetylmorphine were detected in their respective non-biological exhibits. Type of non-biological exhibits, their result, along with the result of connected viscera is given in Table 4.

**Table 3:** District wise list of cases with history of suspected drug abuse

District	Cases	District	Cases
Amritsar	11	Khanna	01
Barnala	02	Ludhiana	05
Batala	03	Moga	08
Bathinda	05	Mohali	02
Faridkot	02	Pathankot	02
Fazilka	03	Patiala	02
Ferozepur	06	Ropar	01
Gurdaspur	02	Sangrur	01
Hoshiarpur	05	SBS Nagar	05
Jalandhar	05	Tarn-Taran	08
Kapurthala	03	Total cases	82

**Table 4:** Significant observations in analysis of viscera and non-biological exhibits

Total cases	Non-biological exhibit	Non-biological exhibit report	Viscera report
10	Syringe with needle	Diacetylmorphine	Morphine
01	i) Syringe with needle ii) Spoon	Diacetylmorphine	Morphine
01	i) Syringe with needle ii) Burnt 10-rupee note iii) Aluminium foil iv) Steel bowl	Diacetylmorphine	Morphine
01	Syringe with needle	Morphine	Morphine
04	Syringe with needle	Diacetylmorphine	Negative
02	Syringe with needle	Morphine	Negative

## Discussion

Drug deaths may occur in epidemics e.g., heroin and methyl alcohol. Sudden death known as overdose or acute reaction is also not uncommon.<sup>10</sup> Identification of the unchanged drug sometimes may become impossible due to substantial lapse of time between the ingestion of a particular drug and death, combined with the various pathways by which the drug is detoxicated.<sup>14</sup> Diacetylmorphine is so rapidly metabolized that no detectable drug may be found in the blood after 30 to 60 minutes of injection. However, morphine alkaloids may be detected.<sup>10</sup> As deacetylation of diacetylmorphine produces morphine in the system, therefore a portion of heroin may be recovered from the tissues as morphine as in our study. Morphine can undergo a change beyond recognition in the system<sup>15</sup>, so this can be the reason why, in many cases of heroin poisoning in our study, morphine was not detected in the viscera. Cases also are known to happen where in undoubted opium poisoning cases, no opium could be identified.<sup>15</sup>

Heroin powder kept on heated silver foil emits fumes that are inhaled by the addicts. In the early stages, although not always in the absolute beginning of the habit, there are sensuous pleasures that may or may not persist. As time goes on, these sensations can only be reproduced by increasing the dose of the drug.<sup>11</sup> Addicts gradually move from inhalation to injections. An addict keeps heroin powder in a spoon, mixes it with tap water, and after heating injects the preparation either intramuscularly or intravenously. Syringes used by addicts for drug abuse allowed direct administration of the drugs into blood (intravenous) and body tissues (intramuscular), resulting in a faster onset of action and a higher rate of absorption. Often it is only through knowledge of certain metabolites that it is possible to adduce any evidence to support the ingestion of their parent compounds.<sup>14</sup> In our study, we reported that in 12 cases morphine was found to be positive in visceral exhibits and diacetylmorphine was found to be positive in non-biological exhibits (mainly syringe with needle) connected with these viscera cases. No common poison (including substances of abuse) was detected in visceral exhibits of six cases while morphine and diacetylmorphine were detected in their respective non-biological exhibits. Thus, we can say that non-biological exhibits can play a crucial role in deciding the source (whether opium or heroin) of morphine detected in visceral exhibits and can also play a role as circumstantial evidence.

A study commissioned by the Ministry of Social Justice and Empowerment in between February and April 2015 on 3620 opioid-dependent individuals across the ten districts of Punjab reported that 76% of opioid-dependent individuals were in the age group of 18 to 35 years and about one-third of the opioid-dependent individuals take their opioid drugs through injecting route.<sup>4</sup> Similar observation was reported in our study that

pattern of overdose differentially affects individuals in the age group of 18 to 35 years, so it becomes necessary to target that subpopulation in Punjab by making them realize the ill effects of drug abuse. With most drug abusers being in the productive age group of 18-35 years in Punjab, the loss in terms of human potential is incalculable. Proper counseling, education, and imparting of necessary life skills are some ways to deal with the menace of drug abuse. Peer pressure, unemployment, myths regarding improved sexual performance, to experience the kick can be the factors for the initiation of substance abuse. Therefore, information related to substance abuse must be included in the curriculum of adolescents to deal with the menace of substance abuse. Parents and siblings should be involved in education programs concerning substance abuse by schools and colleges. Government and various non-government organizations can initiate vocational training and other employment programs for unemployed addicts.

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## Routine preservation of viscera: Is it really required? A Study from Gujarat, India

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### Abstract

At most centers, viscera are routinely preserved in four jars, which involve multiple resources in terms of money, manpower and time. The present study was intended to examine & evaluate the reports of chemical analysis with a hypothesis that if blood tests alone are equivalent to chemical analyses, then the need of viscera preservation may be abandoned. The study was conducted at S. K. Hospital and P. S. Medical College, Karamsad, Gujarat, India. Data were collected from poisoning cases in which autopsy examination was conducted during 2011-15 and routine viscera were preserved in four jars for chemical analyses. Details about their demographic profile, autopsy observations and chemical analysis report findings were incorporated in the validated proforma. Out of 121 alleged cases of poisoning where routine viscera were collected for chemical analyses, 116 cases reported positive findings. Of those 116 cases, blood testing was positive in 101 cases. The remaining 15 poisoning cases were not routine ones. The present study suggests and recommends that sending only blood samples for chemical analyses in place of routine preservation in autopsy poisoning cases will not only satisfy the purpose, but will also be less resource intensive. In some specific cases as per the discretion of the Forensic Expert, viscera can also be sent along with blood

### Keywords

Autopsy; Blood; Chemical analysis; Poisoning; Viscera

### Introduction

It has been observed that cases of ingested poisoning and associated mortalities are quite common in the Indian scenario. As a matter of routine, viscera are preserved during medico-legal postmortem examination of such cases for the purpose of chemical analysis which usually done by a nearby Forensic Science Laboratory. At most of the centers, viscera are routinely preserved in four jars, which involves multiple resources in terms of money, manpower and time. The present study was intended to examine & evaluate the reports of chemical analysis with a hypothesis that if blood tests alone are equivalent to chemical analyses, then the need of viscera preservation may be abandoned.

Autopsies have a significant role in providing an opinion about the cause of death and also for the documentation of external or internal injuries, diseases, and the presence of alcohols, drugs and other substances in body fluids and tissues. Moreover, the autopsy is an important tool in the acquisition of reliable mortality data, which in turn is essential for valid cause of death statistics. National registries of causes of death are generated using the World Health Organization (WHO) International Classification of Diseases (ICD- 10) codes based on

information given in death certificates issued by physicians, and reports from clinical and forensic autopsies.<sup>1</sup> The value of autopsies has already been demonstrated in several studies.<sup>2-8</sup>

Among the Unnatural deaths, Poisoning is an important health hazard and one of the leading causes of morbidity and mortality worldwide. According to WHO data, an estimated 346,000 people died worldwide in 2004 from unintentional poisoning. Of these deaths, 91% occurred in low- and middle-income countries.<sup>9</sup> Poisoning is one of the preferred means of committing suicide among males and females in India but cases due to accidental & homicidal manner have also been reported.<sup>7,8</sup> Viscera like stomach & its content, a piece of the liver, half of each kidney, and blood are being collected as a matter of routine in alleged cases of ingested poisoning.<sup>3</sup> This routine collection of autopsy specimen in four jars is adding to lots of costs to the system and is also delaying investigation due to time required for these samples to be run through various chemical tests.

The objectives of the study included comparing the results of chemical analysis of blood and rest of samples / viscera, assessing the need of preservation of multiple samples / viscera and lastly to prepare recommendations.

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### Materials and Methods

The study was conducted at Shree Krishna Hospital and Pramukhswami Medical College, Karamsad, Gujarat, India. Data were collected from poisoning cases in which autopsy examinations were conducted, routine viscera were preserved in four jars, and chemical analysis reports were received during 1<sup>st</sup> January, 2011 to 31<sup>st</sup> December, 2015 at the Centre for a span of

5 years. Preservative used was saturated solution of common salt (rectified spirit in case of corrosives) and chain of custody was maintained. Details about demographical profile, autopsy observations and chemical analysis report findings were incorporated in the validated proforma.

Statistical Analysis: Descriptive statistics were used to portray the characteristics of the study population. Cross tabulation and exploratory data analysis was performed to ascertain the agreement between forensic medicine expert's suspicion and results of chemical analysis.

## Results

A total of 121 autopsies from 2011 to 2015 were included in the study. The mean (SD) age of the deceased was 33.51(14.68) years with a slightly higher percentage of males 68(56.2%). Gastric lavage was available for 43(35.54%) cases. The controls were stored in sodium chloride 112(92.56%) or rectified spirit 9(7.44%) as per the standard guidelines. None of the controls were found to be contaminated.

**Table 1:** Substances involved in poisoning

Poison	Male	Female	Total
ALP	29	33	62
Monocrotophos	9	4	13
Dichlorovos	15	2	17
Chlorpyriphos	5	3	8
Diamethioate	2	0	2
Forate	1	2	3
Malathion	1	0	1
Ethion	1	0	1
Quinolphos	2	0	2
Endosulphan	1	0	1
Kerosene	1	0	1
HCL	1	5	6
H <sub>2</sub> SO <sub>4</sub> & Phenol	0	1	1
Boric acid	0	1	1
Not detected	0	2	2
Total	68	53	121

The chemical analyses of autopsy specimens could not detect the poisonous substance involved in 5 cases probably due to long standing treatment. Out of these 5 cases, 2 were classified as organophosphate poisoning cases based on the results of gastric

lavage and 1 was classified as a corrosive poisoning based on the treatment record. Aluminum Phosphate (AP) 62(51.24%), Dichlorovos 17(14.05%) and Monocrotophos 14(11.57%) were the most common substances involved (Table 1).

Out of 121 such autopsies, all (blood, stomach/intestine [SI] and liver/kidney [LK]) specimens were positive in 101(83.47%) cases and all the three were negative in the 5 cases. Blood analysis alone was unable to detect the substance only in 15(12.39%) cases. Out of these 15 samples, blood as well as LK was negative in 14 samples but the SI analysis revealed traces of corrosive in 5, ALP in 7, OP in 1 and Kerosene in 1. In one sample where blood analysis was negative, SI and LK both confirmed traces of Boric Acid. The Forensic Medicine expert was not able to suspect the substance in only 3 of these 15 cases as there were no specific findings evident during the autopsy.

The Forensic Medicine expert did not suspect any substance in about half the cases 62(51.24%) whereas he could not ascertain the substance involved confidently in one case albeit suspected poisoning. The agreement between suspicion rose by Forensic Medicine expert and outcome of chemical analysis was excellent (Kappa = 0.81, 95% CI: 0.67, 0.94) (Table 2)

**Table 2:** Agreement between Forensic expert and chemical analysis (n=59)

As suspected by Forensic Expert	As reported on chemical analysis					
	OP	ALP	Corrosive	Kerosene	OC	Negative
OP	17	2	0	0	0	0
ALP	2	28	0	0	0	0
Corrosive	1	0	4	0	0	1
Kerosene	0	0	0	1	0	0
OC	0	0	0	0	1	0
Unknown	1	0	0	0	0	1

## Discussion

The present study found aluminum phosphide as a commonest type of poisoning, followed by organophosphates. Similar observations were seen by many authors and are available in the literature.<sup>3,4,7,8</sup> Out of 121 cases, blood analysis was found positive and confirmatory in 106 cases of poisoning which is a statistically significant finding. This suggests that blood analysis alone can replace the need of collecting many specimens for chemical analyses purposes as a matter of routine. In some specific cases, other samples and specimen can also be forwarded for chemical analysis depending upon the nature and type of the case. The blood only to be preserved in routine case but in specific cases this does not rule out preservation of other samples and viscera. There is a probability

of false negative result with blood only preservation among the samples i.e. in cases where toxic substance traces are still present in stomach or intestine or liver and kidneys but blood examination for the same may not be positive due to any fallacy; in cases where toxic substances are dissociated into the metabolites or at the end-organs pathway; in cases where post-mortem manipulation by insertion of the toxic substances was being carried out. These may be disadvantages of the blood-only preservation among the samples but such scenarios exist rarely and may be neglected while considering routine preservation. But consciousness about this will not only save resources but also help in timely investigations by law enforcement agencies. In the Indian scenario, chemical analyses laboratories are not well equipped to identify most poisons. Satinder PS et al in their study found only three types of poisons (aluminium phosphide, organo-chlorides, and organo-phosphorus compounds) and explained that the “concerned chemical examination laboratory is not examining the viscera for other poisons” as the reason.<sup>4</sup> One explanation for this may be that chemical examination laboratories in India may be overburdened. In this study, chemical analysis report stated that scientific officer at the Forensic Science Laboratory used 'Standard Chemical Analysis' procedures for detection of chemically toxic substances. As this study was carried out as a pilot project, for further study on a large scale, it shall be studied whether blood only sample shall be sufficient for chemical analysis or other samples shall be required for comparison of values in viscera and blood. Present findings about sending only blood samples as a matter of routine is therefore very pertinent in this scenario. Authors were unable to find literature with regards to the study subject, so discussion and comparison with other studies is beyond purview.

## Conclusion

The present study suggests and recommends that sending only blood samples for chemical analyses for routine preservation in autopsy poisoning cases will not only satisfy the purpose but also be less resource intensive. This observation if implemented may also be helpful for rapid investigations by law enforcement agencies.

The observations of our pilot study needs to be carried forward on a large scale with more samples to identify statistical

significance on a large scale. Involvement of scientific officer from forensic science laboratory shall be carried out to study whether blood only sample shall be sufficient for chemical analysis technically as well as for comparison of values.

**Ethical clearance:** A prior approval was obtained from the Institutional Ethics Committee of H M Patel Centre for Medical Care and Education, Karamsad, Gujarat, India.

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## Potential use of cranial morphology in identification of monozygotic twins: A preliminary study

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### Abstract

Twins occur in about 1 in 85 human birth. Monozygotic twins are thought to be genetically indistinguishable yet can show high variability in their phenotypes. This difference and variability may be attributed to the various parameters like external factors and the role of epigenetic polymorphism. This paper aims at studying the various cephalometric measurements on the lateral cephalogram to aid the investigators in identification of identical twins. A study on ten pairs of twins lateral cephalogram was performed in order to examine the cephalometric landmarks of cranium under controlled condition. After a thorough metric analysis, it can be stated that there are considerable variations in cephalometric dimensions of monozygotic twins.

### Keywords

Cephalometry; Cephalic Index; Lateral Cephalogram; Monozygotic Twins etc.

### Introduction

Cephalometric investigation is normally utilized by Dental practitioners and Orthodontists to consider skeletal morphology in the Craniofacial complex.<sup>1</sup> Comparison of monozygotic and dizygotic twins is frequently used to partition research of quantitative traits into environmental and genetic factors.<sup>2</sup> Cephalometric studies to determine the heritability of certain craniofacial parameters malocclusion cases and also, can be used to presume future changes.<sup>3</sup> Cephalometry, the study of measurement of dimensions of the upper part of human body i.e., head and face, by taking the image of head medically such as by taking radiographs or by craniometry (by taking the measurements of skull) especially in the duration of developing and growing stage.<sup>4</sup> Genetic mechanisms are already prominent during embryonic craniofacial morphogenesis but environment is also thought to influence dentofacial morphology.<sup>5</sup> The history of cephalometry can be traced through art, science and anthropology.<sup>6</sup> This research paper focusses on the cephalometric measurements of the monozygotic twins which has not been studied earlier.

Cephalometric investigation relies upon cephalometric radiography to study connections in the middle of hard and delicate tissue points of interest and can be utilized to analyze facial development variations from the norm preceding treatment, amidst treatment to assess progress or at the conclusion of treatment to discover that the objectives of

treatment have been met.<sup>7</sup> Lateral Cephalometric radiograph is a radiograph of the head brought with the X-ray beam opposite to the patient's sagittal plane.<sup>7,8</sup> Regular head position is a systematized introduction of the head that is reproducible for every person and is utilized as a method for examination of dento-facial morphology.

### Material and Methods

The present study was carried out in the Amity Institute of Forensic Sciences, Amity University Noida. A total of 10 cephalograms of monozygotic twins (i.e. 20 participants) belonging to same geographical area and race were collected from orthodontic clinics of NCR region and included in the study. Approval was taken from the institutional ethical committee, Amity Institute of Forensic Sciences (AIFS) The consent from the parents of monozygotic twins (participants) was taken prior to each investigation.

Participants included for the study were above the age of 12 years for the reason that the cranium in humans continues to develop till the age of 12 years, and that the eruption of permanent teeth is generally complete by the age of 12 years. The participants had healthy state of gingiva and the periodontium. The subjects with previous history of orthodontic treatment/orthognathic surgeries. Any evidence of systemic disease or any craniofacial abnormality like cleft lip and palate.

Cephalometric tracing used in the study is a superimposed drawing created from cephalometric radiographs with a lead pencil in contact with acetic acid derivation paper, utilizing a bright light involving various landmarks (Figure 1). The dimensions involve angular, linear, coordinate, and arcial relationships to acknowledge information about the maxillary location, mandibular location, facial proportions/vertical dimensions, and incisor location (both maxillary and mandibular) of a person was considered for the study and the

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observations were noted as per Steiner's Analysis.<sup>10</sup>

The parameters undertaken for the research includes the following:

- N (Nasion): The most anterior point of the frontonasal suture in the midsagittal plane
- S: Midpoint of sella (the center of sellaturcica).
- A Point (Subnasal): The deepest midline point on the anterior outer contour of the maxillary alveolar process.
- B Point (Supramentale): The deepest point on the outer contour of the mandible.
- ANS (Anterior Nasal Spine) the most anterior point of the tip of the anterior nasal spine in the mid-sagittal plane.
- PNS: Posterior Nasal Spine.
- Me (Menton): The most inferior point of the outline of the symphysis in the mid-sagittal plane.
- Go (Gonion): A point at the intersection of lines tangent to the posterior border of the ramus and the lower border of the mandible.
- SNA angle: The sagittal position of the maxilla relative to the cranial base using A-point as a cephalometric landmark.
- SNB angle: The sagittal position of the mandible relative to the cranial base using B-point as a cephalometric landmark.
- ANB angle: The sagittal relative position of the maxilla to mandible. The ANB angle can be measured or calculated from the formula: ANB = SNA-SNB
- B angle: The angle between mandibular and maxillary plane
- UII (Upper incisors inclination): The angle of the long axis of an upper central incisor from a maxillary plane.
- LII (Lower incisors inclination): The angle of the long axis of a lower central incisor from a mandibular plane.

**Table 1:** Lateral cephalometric measurements among monozygotic twins (in cm)

Landmark	S-N	N-A	N-B	N-ANS	S-PNS	S-Me	S-Go	A-B	PNS-ANS	ANS-B	PNS-Me	Ge-Gn	Ms-c
S1(a)	7.1	5.6	10.2	5.3	4.8	11.9	8.2	4.8	4.3	5	7.2	6.7	3
S1(b)	7.4	6.5	11.5	5.4	5.4	13.2	9.1	5.2	4.8	6	7.9	7.6	3.4
S2(a)	7.2	7.3	12	7	5.2	13.1	8.2	4.8	6.2	5.4	8	9.1	3.7
S2(b)	7.4	7.2	12	6.8	5.3	13.4	8.7	5.3	6.9	6.2	8.1	8.9	3
S3(a)	7.5	6.9	10.9	6	5.8	14.6	11.1	4.1	6.7	5.2	9	8.7	3.5
S3(b)	8.7	6.4	11.3	6	6.1	14.8	9.7	5	7.3	5.5	8.9	9.3	3.4
S4(a)	5.6	5	9.3	5	4.6	11.8	6.9	4.7	6	5.3	7.3	7.2	3.3
S4(b)	6.1	5.1	9.9	5.3	5	12.9	8.3	4.3	6.4	5	7.5	7.8	4.4
S5(a)	-	-	-	-	4.7	11.9	8.6	4.7	4.7	5.3	7.3	6.9	3.4
S5(b)	-	-	-	-	-	12	8.1	-	4	-	7.7	-	-
S6(a)	7.2	6.2	10.8	5.3	4.8	11.2	8.6	4.9	4.4	5.3	7.4	6.8	3.2
S6(b)	7.4	6.5	11.5	5.6	5	12.4	9.2	5.4	4.9	6.1	8	7.7	3.7
S7(a)	7.3	7.4	12.3	7.4	5.3	13.2	8.3	4.9	6.3	5.6	8.2	9.3	3.9
S7(b)	7.5	7.5	12	6.9	5.4	13.6	8.9	5.6	6.8	6.3	8.6	8.9	3.3
S8(a)	7.6	6.4	10.8	6.1	5.7	14.3	11	4.4	6.9	5.4	9.3	8.5	3.7
S8(b)	8.4	6.9	11.2	6.2	6.2	14	9.9	5.1	7.1	5.6	9.1	9.6	3.3
S9(a)	5.6	5.8	10.3	5	4.6	11.8	6.9	4.7	6	5.3	7.3	7.2	3.3
S9(b)	6.1	5.5	9.9	5.3	5	12.9	8.3	4.3	6.4	5	7.5	7.8	4.4
S10(a)	7.1	6.9	11	-	4.7	12	8.7	4.8	4.8	5.6	7.1	6.4	3.5
S10(b)	7.6	-	11.2	5.6	5.1	12.3	8.3	4.3	4.6	5.4	7.3	6.6	3.8

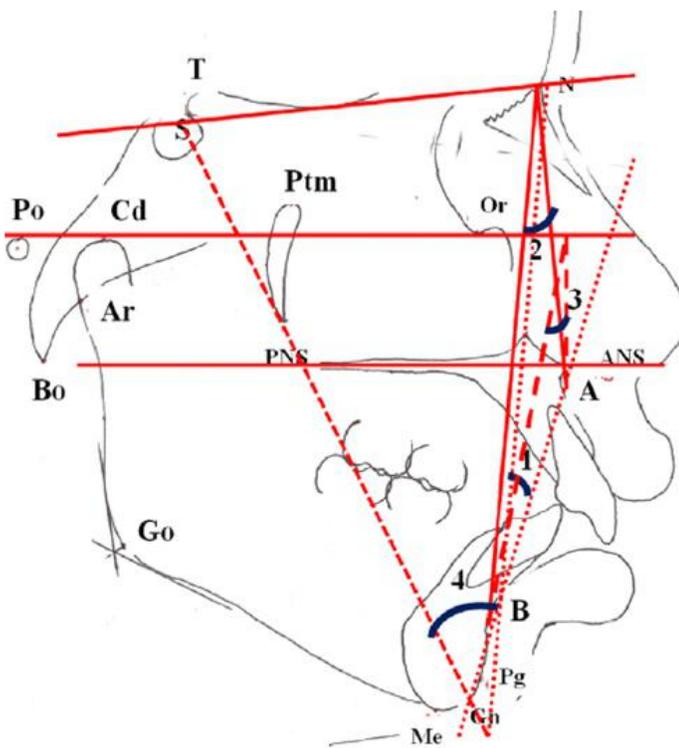


Figure 1: Various landmarks on the Cephalometric tracings

## Result

Lateral cephalometric measurements (in cm) of the 20 participants are shown in Table 1 for comparisons. After all-inclusive examination of the samples it was observed that the cranial morphology showed differences among the monozygotic twins. The statistical significance of the differences however, could not be seen because of the small sample size, which can be considered as a limitation of the study.

## Discussion

Each person has an identity; the need for this identity is paramount to distinguish between twins as well. The purpose of the present study was to analyze whether it is possible to distinguish between monozygotic twins based on cranial measurements. It is well established that the growth and development of the dento-facial complex is an intricate phenomenon and are under the influence of genetic, environmental and epigenetic factors. Although monozygotic twins share both identical genetic make-up and very similar environments, they are not 'identical'.<sup>11,12</sup>

Many research works have already been done on cephalometry. Dr. Frans Linden, 1996, described a permanent interaction between genetic and environmental factor, both of a continually altering nature, determines the dento-facial morphology in

every moment of life.<sup>13</sup> Carels, 2008, described the relative genetic and environmental impact on a number of well-known cephalometric variables in twins and Tonya White,<sup>14,15</sup> had described, monozygotic twins share an identical genetic compliment, they provide a unique opportunity to explore the genetic and environmental determinants of brain development.<sup>14,15</sup>

Findings to the craniofacial profile in adult MZ twins have not previously been described in the literature. Analyses of the cervical column and comparison of the findings to the craniofacial profile in adult MZ twins have not previously been described in the literature. Analyses of the cervical column and comparison of the findings to the craniofacial profile in adult MZ twins have not previously been described in the literature. Most of these previous studies focus on dento-facial characteristics and pathologies the contributing role of genetics for being able to utilize it as a tool in diagnosis and treatment planning in Orthodontics.<sup>16-19</sup> Other studies also report that there is considerable variability observed in monozygotic twins regarding various components of cranio-facial complex in terms of relative size, shape and 3D arrangement of bony components of craniofacial skeleton.<sup>20,21</sup> The findings of the present study are consistent with other studies reporting variations in monozygotic twins. But the comparative cephalometric analysis of craniofacial profile in monozygotic twins for the purpose of personal identification has not previously been described in the literature. Though identical twins are thought to be 100% similar in every aspect but they do have considerable differences in cephalometric measurements which can be very useful in personal identification cases where DNA profiling will not yield fruitful results. This study shows that monozygotic twin pairs demonstrated intra-pair variation in terms of metrics and spatial arrangement of skeletal components of face. Analyses of the cervical column and comparison of the findings to the craniofacial profile in adult MZ twins have not previously been described in the literature

## Conclusion

This study represents a preliminary attempt to distinguish between monozygotic twins based on the cephalometric measurements. Based on the results of this study it is reasonable to assert that there is variation in craniometric measurements of monozygotic twins, As the sample size is limited further studies are necessary. In future studies an attempt to conduct the research on large sample size is intended.

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

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## Comparison of morphological measures of nasal bone between genders using computed tomography

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### Abstract

Facial anthropometry plays an important role in forensic investigations especially in identification of decomposed bodies from skeletal remains. Dimensions of nasal bone is one such parameter that can be used to determine sex. The main aim of the study is to compare the morphological measures of nasal bone between genders using computed tomography. This is a retrospective study on the patients visiting the Dept. of Radiodiagnosis and Imaging, Kasturba Hospital, Manipal. Based on the inclusion and exclusion criteria, 240 subjects (120 males and 120 females) who were referred for routine CT OMC were included in the study. The axial sections were converted into coronal and sagittal slices using the multiplanar reconstruction tool. Three anthropometric parameters were measured. A total of 240 (120 males and 120 females) data was obtained with age group ranging from 20-50 years. Mean and Standard deviation was calculated. The data was normally distributed hence independent sample T test was performed to find the difference between males and females. Null hypothesis stated that there was no significant difference based on the anthropometric measurements between the males and females since the ( $p > 0.05$ ). Alternate hypothesis stated that there is significant difference noted between the males and females ( $p < 0.001$ ). In present study, three measurements of the nasal bone were taken such as the nasofrontal angle, pyramidal angle and the linear distance out of which two variables i.e. the pyramidal angle and the linear distance were good discriminators which contributed high accuracy in comparison to the other parameter.

### Keywords

Nasal Anthropometry; Gender Discrimination; Computed Tomography

### Introduction

Facial anthropometry plays an important role in forensic investigations especially in examination and identification of decomposed bodies from skeletal remains.<sup>1,2</sup> The objective of such skeleton examination includes determination of race, sex, estimation of age, physique, ascertaining the cause of death, time since death and manner of death. When the skeletal remains are recovered in as broken or fragmented state, the individual's bones or parts of bones are used. The use of the dimensions of nasal bone is one such parameter that can be used to determine sex.<sup>2,3</sup> Measurements of nasal bone parameters such as the Nasofrontal angle and the pyramidal angle play a key role in forensic medicine and can be used to estimate the gender and age in various situations. Therefore, research on the nasal parameters of various ethnic groups is very important. Nasal analysis is also vital before performing rhinoplasty (plastic surgery) as well as in the evaluation and diagnosis of craniofacial deformities. The nose is the uppermost

part of the respiratory tract and the organ for smell.<sup>2,4</sup> Its shape including the nasal bridge, slope of the tip, septum and nares differs from race to race, tribe to tribe and from one environmental region of the world to the other. The nasal bone consists of two symmetric bones that are situated side by side at the middle and upper part of the face between the maxillary (upper jaw) bones' frontal processes. They are situated midline to each other, forming the bridge of the nose. Nasal bones are normally small and oblong but can differ in size and shape in different people. CT imaging represents a reasonable, reproducible and precise method for the normal nasal dimensions because of the high contrast resolution. Moreover, it eliminates measurement limitations of conventional radiographs.<sup>5</sup> This flexible modality allows both 2D and 3D data acquisition and can be viewed in all three planes. Furthermore, it helps in the easy interpretation of the anatomic, physiologic and metabolic investigations of various parts of the body allowing the exact identification of the internal structures and the extent of the located problem.<sup>6,7</sup> Therefore, the present study was conducted with an aim to compare the morphological measures of nasal bone between genders using computed tomography.

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### Materials and Methods

The approval for this study was acquired from the Institutional Research Committee, SOAHS and Ethics committee KH.

Considering the inclusion and exclusion criteria 240 subjects (120 males and 120 females) who were referred for routine Computed Tomography of Brain and CT of Osteo Meatal Complex by referring physicians were included in the study. Informed consent was acquired after the study procedure was explained to the subjects involved. CT scan was performed using a 64-slice, Philips Brilliance Multi-Detector Computed Tomography in the Dept. of Radio-diagnosis and Imaging, Kasturba Hospital, Manipal. CT Osteo Meatal Complex was done on Multi-Detector Computed Tomography Brilliance 64 slice Phillips with the normal routine protocol. Patients appointed for CT Osteo Meatal Complex were positioned on the CT couch in supine head-first position, with the area coverage of the Sella to the frontal sinus. Computed Tomography of Brain was also done on MDCT Brilliance 64 slice Phillips with the normal routine protocol. Patients appointed for the scan were positioned on the CT couch in supine head-first with an area coverage from C1 to the vertex.

Scanogram was acquired in caudocranial scan direction with no gantry angulation in the lateral position for both protocols having exposure factors of 120 kVp and 30 mAs. Axial sections of the nasal bone were acquired with a slice thickness of 0.9mm and a slice increment of 0.45mm with filter of detail D producing a high bone resolution on CT OMC and with an additional recon having a slice thickness of 1.5mm and a slice increment of 0.75mm with filter of brain sharp C producing a standard resolution on Computed Tomography of brain. The acquired axial sections were converted to sagittal orientation using MPR (Multi-planar Reconstruction) tool with Phillips CT viewer software that allows 2D and 3D post-processing.<sup>6</sup>

Three anthropometric parameters namely Nasofrontal angle the angle formed between the nasal bone and the frontal bone, Pyramidal angle is the angle formed between the bilateral nasal bones. The linear distance between the nasion and the tip of the nasal bone were measured on different planes of the CT scan images. On mid-sagittal CT scans, a point A was set at the most protuberant point of the glabella. A point B was set at the nasion, which was the center of the Nasofrontal suture, and C at the nasal bone tip, which was the most protuberant and lowest point of the nasal bone. Not only the angle formed between A, B, and C but also the linear distance between B and C was then measured which is shown in Figure 1 and 2.

On axial CT scans, the pyramidal angle at the level of the nasal root, the level of the tip of the nasal bone, and the middle of the two levels were measured. A point D at three levels: the level of the nasal root (the top of the nose, forming an indentation at the suture where the nasal bones meet the frontal bone), the middle level (the actual middle point between the nasal root and the tip of the nasal bone), and the level of the tip of the nasal bone (the most protuberant and lowest point of the nasal bone). In addition, points E and F at the tangent points derived from D to

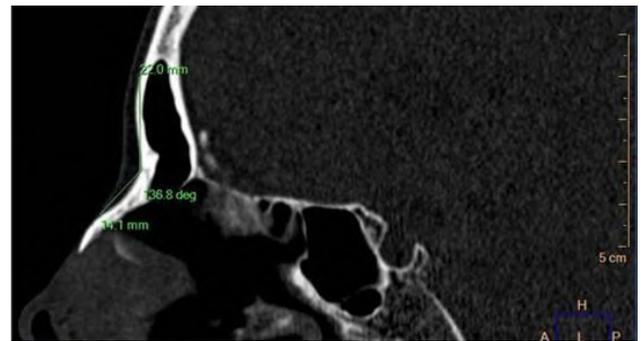


Figure 1: CT scan image of 2D sagittal section showing the measurement of linear distance between the nasion and tip of nasal bone.



Figure 2: 3D CT image showing the measurement of linear distance between the nasion and tip of nasal bone.



Figure 3: 2D Axial section showing the measurement of Pyramidal angle



Figure 4: 3D CT image showing the measurement of Pyramidal Angle

the right and left nasal bones, were set respectively. Then, the angle formed between D, E, and F was measured which is shown in Figures 3 and 4. The data obtained was analyzed using Social Package of Statistical Science software (SPSS, version 20.0) and descriptive statistics were calculated.

## Results

From total sample size of 240 (120 males and 120 females), Data was collected from a total sample of 206 subjects, out of which 102 were males and 94 were females between the age group of 20-50 years. The data was randomly selected independent of age for patients between the ages of 20-50. Descriptive analysis was performed to find the mean and standard deviation which are shown in Table 1. It was found that the values for the anthropometric parameters of nasal bones of both males and females were normally distributed. Hence independent sample t Test was performed. The null hypothesis stated was that there is no significant difference between means of the Nasofrontal angle, pyramidal angle and linear distance between males and females whereas the alternate hypothesis states that there is a significant difference between the means of the Nasofrontal angle, pyramidal angle and linear distance between males and females. The pyramidal angle and linear distance were statistically significant ( $p < 0.001$ ) with the value being greater in males compared to females for the linear distance and greater in females compared to males for the pyramidal angle whereas the Nasofrontal angle was more in females compared to males without any statistical correlation. The degree of freedom and the confidence interval was calculated for all the parameters which is shown in Table 1.

**Table 1:** Mean, and standard deviation (S.D) of Nasofrontal angle, pyramidal angle and linear distance of males and females

	Gender	N	Mean	S.D	t	P	95% CI
Nasofrontal Angle	Male	112	140.803	6.984	-0.571	0.569	(-2.309, 1.272)
	Female	94	141.321	5.984			
Pyramidal Angle	Male	112	57.311	8.189	-5.182	<0.001	(-6.857, -3.077)
	Female	94	62.278	5.486			
Linear Distance	Male	112	126.323	8.850	7.430	<0.001	(5.863, 10.099)
	Female	94	118.323	6.535			

## Discussion

Different measurements of human individuals were used for understanding human physical variations that are done by a series of systematized measuring techniques which quantitatively express the dimensions of the human skeleton. These measurements are mostly used in forensic studies to determine the difference in sexual dimorphism between genders.<sup>8</sup>

In present study, three parameters were measured namely the Nasofrontal angle, the pyramidal angle and the linear distance.

The p value for pyramidal angle and linear distance showed significant statistical difference having a higher value in males as compared to females for the linear distance and having a higher value in females as compared to males for the pyramidal angle, hence indicating sexual dimorphism. Unlike biometric analysis, radiological anthropometry is the measurement of the distance or angle between two points on a projected plane. However, because the 3-dimensional stereoscopic location of the face is determined in a 2-dimensional manner, there might be some discrepancy in the magnitude of the measurements, depending on the sites, between radiological anthropometry and biometric analysis.<sup>2</sup>

Kyung Min Moon *et al*, performed a study on Nasal Anthropometry on Facial Computed Tomography Scans for Rhinoplasty in Koreans and found the mean pyramidal angle to be 117.49° in males and 115.60° in females.<sup>2</sup> The present study shows a mean pyramidal angle of 57.31° in males and 62.23° in females indicating a high difference in females than in males.

A Kalha *et al*, in the year 2008, performed a study in which "Soft tissue cephalometric norms of South Indian ethnic population were assessed on lateral cephalograms taken in natural head position. A total of 60 normal subjects (30 men, 30 women) were analyzed using a soft-tissue cephalometric analysis for orthodontic diagnosis. The results showed that: men have a flatter occlusal plane than women; men have thicker soft-tissue structures and also more acute nasolabial angles than women; men have longer faces compared with women; women have greater interlabial gap and maxillary incisor exposure than men; and in the midface region, men had more deep-set facial structures than women. The present study measured lateral cephalograms using computed tomography and had a slightly higher mean value in males than in females which indicates sexual dimorphism and coincides with the findings of A Kalha *et al*'s study.<sup>9</sup>

The present study has certain limitations as due to unviability of enough time data collected from number of female subjects were less. Based on the literature survey, no reports were found to provide facial measurements of the nasal pyramidal angle in Indians. Our results showed that the mean value of the nasal pyramidal angle was 57.31° in the male patients and 62.27° in the female patients. It should also be noted that there was a variability of the nasal parameters among individuals. These results might be of use to forensic anthropologists as well as when performing rhinoplasty in Indian population.

## Conclusion

In the present study, various parameters were taken into consideration out of which pyramidal angle and the linear distance were good discriminators of gender and contributed to a considerable separation with high accuracy.

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**Ethical clearance:** A prior approval was obtained from the Institutional Ethics Committee of Kasturba Medical College & Hospital, Manipal with Reg.No- (ECR/146/Inst/KA/2013). The data was obtained from the subjects who were scheduled for the routine procedure in the department.

**Conflict of interest:** None to declare

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## Study of Cephalic Index in medical students of West Bengal

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### Abstract

Human beings are always very much interested in making comparison over other creatures to prove their superiority. Different types of measurements are important tool for comparative study, related to various characteristic features. Craniofacial measurement especially cephalic index is an important tool among those comparative studies, useful in determining different head and face shapes. Present study is going to be carried out with an objective to find out Cephalic Index of Medical Students of West Bengal. Total 325 young and healthy medical students were taken as subjects, whose head length, head breadth were measured. Cephalic indices of the subjects were calculated by Hrdlicka's method. Most of the subjects were found mesocephalic, 59 % male & 51.7 % female. Mean cephalic index in male  $78.45 \pm 2.44$  and for female  $77.65 \pm 3.58$ . Mean cephalic index irrespective of gender was found  $80.5 \pm 3.67$ . This study showed the head type of students in West Bengal was mesocephalic predominant. This statistically significant data can be utilized by anthropologist or forensic expert.

### Keywords

Cephalic index; Head length; Head breadth

### Introduction

Dimensions of human body are changed by ecological, biological, geographical, racial, sex and age factors.<sup>1</sup> Comparative study related to these changes may disclose a vital clue for transmission of genetic information for inherent human character. Anthropometric measurements in respect to craniofacial measurement are an important tool among those comparative studies, useful in determining different head and face shapes.<sup>2</sup> The most important cephalometric dimensions are length and breadth of head which comprise the cephalic index. The Cephalic Index was defined by Swedish professor of Anatomy Anders Retzius and first used in physical anthropology to classify ancient human remains found in Europe.<sup>3</sup> Now a day, cephalic index is being used to distinguish a given sample or individual into race, sex etc.<sup>4</sup> In this way, comparative analysis in cephalic index may help to understand the frequency distribution of human morphology. Hence in the present study, cephalic index of medical students of West Bengal was studied to generate the statistical data on morphometry.

### Materials and Methods

Total 325 young and healthy medical students, 213 males and 112 females, aged between 18 to 25 years, without any disease

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or deformity were taken as subjects. Study was carried out with protocol presentation and followed by institutional ethical clearance. Students were asked to sit in a relaxed state, straight and looking forward. Measurements of head length and head breadth were taken using slide calipers. All the measurements were taken between 10.00 am to 12.00 pm by the same observer. To minimize subjective errors all the measurements were taken three times and then mean was taken.

The head length was measured from summit of glabella toinion (occipital point) in cm. The head breadth was measured in cm as a distance between two parietal eminences. Cephalic Index was calculated on the basis of international description<sup>5</sup> using Hrdlicka's method as; head length/head breadth  $\times 100$ . The head shapes were classified on the basis of cephalic index as described in literature.<sup>5</sup>

Observed data was analyzed statistically using SPSS version 16 to calculate the mean, standard deviation (SD) and the descriptive statistic are presented in tables. Unpaired student t test was applied for comparison between genders.

### Results

The observations in respect to the head length and head breadth of male and female subjects are shown in Table 1. Mean cephalic index irrespective of gender was found  $80.5 \pm 3.67$ . Mean cephalic index in males and females was  $78.45 \pm 2.44$  and  $77.65 \pm 3.58$  respectively.

The dominant type of head shape in this study was mesocephalic (56.63%), followed by brachycephalic (26.76%), hyperbrachycephalic (12.61%) and dolicocephalic (4%). Distribution of participants according to type of cephalic index and relationship of sex with type of cephalic index is shown in Table 2.

**Table 1:** Cephalometric measurement (N= 325)

Parameter	Male			Female		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Head length	15.8	19.7	17.75	13.5	17.9	15.7
Head breadth	12.6	15.5	14.05	11.3	14.7	13.1
Cephalic index	71.3	89.6	78.45	72.8	88.3	77.65

**Table 2:** Distribution of participants according to type of cephalic index

Type	Cephalic index	Total (%)	Male (%)	Female (%)
Dolichocephalic	65-74.9	13 (4%)	9 (4%)	4 (3.5%)
Mesocephalic	75-79.9	184 (56.6%)	126 (59%)	58 (51.7%)
Brachycephalic	80-84.9	87 (26.8%)	52 (24.4%)	35 (31.2%)
Hyperbrachycephalic	85-89.9	41 (12.6%)	26 (12.6%)	15 (13.6%)
Total		325 (100%)	213 (100%)	112 (100%)

## Discussion

According to Stewart classification,<sup>5</sup> our study group that is the Bengali population belongs to mesocephalic, as the mean cephalic index is  $80.5 \% \pm 3.67$ . Bhargar et al.<sup>6</sup> in 1960 found mean cephalic index 76.9 in Bhils and in 1961<sup>7</sup> and 79.80 on Barelals, both the findings come under mesocephalic. Shah et al.<sup>8</sup> found cephalic index 80.81 for Gujarati population, classified as mesocephalic, whereas study carried by Bhasin et al.<sup>9</sup> observed, brachycephalic elements among Indian population groups with mongoloid. Khair et al.<sup>10</sup> (78.48), Mishra et al.<sup>11</sup> (77.79) and Patro et al.<sup>12</sup> (77.55) found cephalic index which are lower than our study value. Mahajan et al.<sup>13</sup> (81.31) and Nair et al.<sup>14</sup> (85.53) showed higher results than our study value.

In present study mean cephalic index in male was 78.84. Lower value of mean cephalic index in male found by Kiran et al.<sup>2</sup> (77.92), Mishra et al.<sup>11</sup> (78.45), Patro et al.<sup>12</sup> (77.28) and Salve et al.<sup>15</sup> (75.68) in their study. But higher value than our study result showed by Khair et al.<sup>10</sup> (81.28), Uttekar et al.<sup>16</sup> (81.24), Nair et al.<sup>14</sup> (81.34) and Mahajan et al.<sup>13</sup> (81.21).

We found the mean cephalic index for female was 77.65% in our study. Khair et al.<sup>10</sup> got lower value than us 75.22. But Patro et al.<sup>12</sup> (78.38), Salve et al.<sup>15</sup> (78.20), Kiran et al.<sup>2</sup> (80.85), Mahajan et al.<sup>13</sup> (85.75), Mishra et al.<sup>11</sup> (79.05), Kumara et al.<sup>17</sup> (79.25) and Nair et al.<sup>14</sup> (80.31) found higher value.

## Conclusion

West Bengal has a predominance of mesocephalic head. Findings on cephalic index vary significant according to ethnicity. Variation in shapes of head may be due to hereditary factor play vital role. Analytic result of our study thus may be useful for comparison in

regional and racial differences among different population especially to anthropologist and forensic medicine experts.

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## Utilization of forensic odontologic findings in solving the unsolved cases: A retrospective study

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### Abstract

Forensic dentistry or dental jurisprudence may be defined as the application of dental sciences to the administration of law. Forensic dentistry includes studying a lot of topics such as individual identification, mass identification, as well as bite mark analysis. Forensic odontology has gained more importance in western countries and is considered as reliable evidence in solving criminal cases. With increasing crime in India, as given by the National Crime Records Bureau over 6.4% each year, the numbers of studies are assessing the utilization of forensic odontological findings in solving criminal cases in India. A retrospective study was done in Puducherry and Tamil Nadu in December 2018. A well-structured, pre-tested performa was adopted from the study conducted by Senthil et al in the year 2012 and modification was done. After explaining the intent of the study, permission was obtained from the Director of forensic sciences department Puducherry and Tamil Nadu. Secondary data regarding the use of forensic odontological findings in solving criminal cases were collected from 2987 cases. The data were then entered into the Microsoft Excel spreadsheet. Descriptive statistics were done using SPSS software (version 20). There were only 3 cases that have been solved using forensic odontology findings. Only antemortem and post-mortem reports were used in these cases. The duration of data relied upon was 1 to 3 years from the investigation. The victim's dentist was identified from the victim's relatives. The findings of the current study show under-utilization of forensic odontological findings in the investigation of the criminal case.

### Keywords

Forensic dentistry; Criminal case; Person identification; Forensic odontology; Law

### Introduction

Human being has come across a long way from the early Stone Age to the present 21<sup>st</sup> century covering nothing less than heights of sky to sea bed depths. His zeal to conquer new heights has created enormous scientific advancements and technologies. However, his intelligence has also led to a surge in crime rate, terrorism, wars, mass disasters, road traffic accidents, and dreadful diseases.<sup>1</sup> The term crime denotes an unlawful act punishable by a state.<sup>2</sup> Police department is the primary law enforcement agency of a state which controls the crime of that state. Forensic scientists help police departments with the collection, preservation, and analysis of scientific evidence during an investigation.<sup>2</sup>

Forensic odontology has become a vital and integral part of forensic science. This discipline plays a significant role in the identification of human remains in incidents such as tsunamis, earthquakes, landslides, bomb blasts, and terrorist attacks, airplane crashes, train and road accidents, etc. where highly mutilated and dismembered dead bodies are recovered which

are beyond recognition.<sup>3,4</sup> This process of identification of the disaster victims is known as Disaster Victim Identification (DVI). Teeth are the strongest part of the human body, which can withstand high explosion and are not damaged by such incidents.<sup>5,6</sup> Thus, teeth are likely to be recovered in mass fatality incidents where the other means of identification such as fingerprints and facial features are destroyed.<sup>7</sup>

The teeth, lip pattern, rugae patten and other odontological feature are unique to an individual. Bite marks inflicted by the teeth are considered to be highly individualistic to a person and are hence of considerable importance from a forensic point of view.<sup>8,9</sup> In India, qualified forensic odontologists are very few in number and odontological findings are underutilized in solving criminal cases. So, an attempt should be made to reinforce awareness and importance about the role of dentists in person identification and to awaken the social responsibility among practicing dentists of maintaining dental records of all the patients.<sup>10</sup> This study aims to assess the utilization of forensic odontology findings in crime investigations.

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### Materials and Methods

A retrospective study was carried out in Puducherry and Tamil Nadu between December 2018 and January 2019. All 2987 records of cases reported in the last five years in Forensic Science Departments of respective states were assessed. The anonymity of the records was maintained. Ethical approval for

performing this study was obtained from the Institutional Ethical Committee of Saveetha Dental College.

A well-structured, pre-tested Performa was adopted from the study conducted by Senthil et al.,<sup>11</sup> in the year 2012 and modification was done. The modified questionnaire was tested by Expert review. The expert panel included an advocate, an official from the law department and a forensic scientist. The first section collected demographic information of the case files such as gender, year and month when the case was referred to the forensic department. The second part consisted of details regarding types of services utilized, type of death, type of forensic report, weather forensic odontology were utilized for the cases and if used, the type of forensic odontological analysis done. After a brief introduction to the purpose and intent of the study, data was collected from the Forensic science department Tamil Nadu and Puducherry. Data were then entered into Microsoft Excel spreadsheets and analyzed using SPSS software (version 20). Descriptive statistics were used.

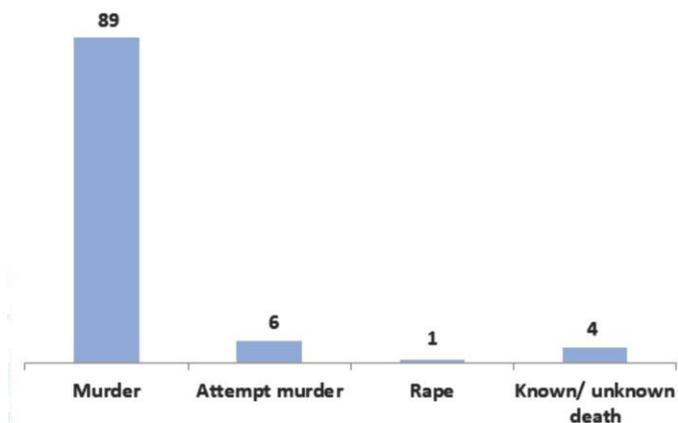
### Results

A total of 2987 cases were recorded which included 461 cases from Puducherry and 2526 cases from Tamil Nadu. 272 cases from Puducherry and 1785 cases from Tamil Nadu were session cases (Murder, attempt to murder, rape and grievous injuries) and 189 cases from Puducherry and 741 cases from Tamil Nadu were Preliminary Registered Cases (Table 1).

**Table 1:** Distribution of criminal cases based on location

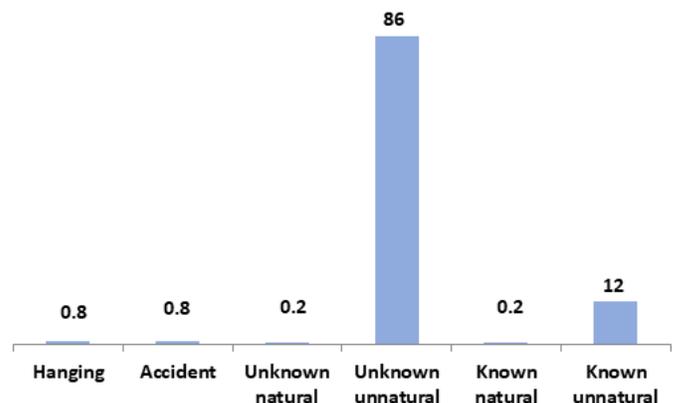
Area / type of case	Sessions case (%)	PRC case (%)	Total (%)
Puducherry	272 (59)	189 (41)	461 (100)
Tamil Nadu	1785 (71)	741 (29)	2526 (100)

Among 2987 cases, 89% were murder cases, 6% were attempt murder cases, 4% were known or unknown cases and 1% constituted rape cases (Figure 1).



**Figure 1:** Type of criminal cases in percentages

The reason for death among 2987 cases included 86% unknown unnatural death, 12% known unnatural death, 0.8% each hanging and accident and 0.2% each unknown natural and known natural death (Figure 2).



**Figure 2:** Distribution of criminal cases in percentages, based on manner of death

Among the 2987 cases recorded, only 3 criminal cases were solved utilizing forensic odontologic findings. All these cases were solved using antemortem and post-mortem records and the victim's dentist was identified from relatives. The duration of data relied upon was 1 to 3 years from the investigation.

### Discussion

Forensic dentistry is a field of dentistry concerned with the correct management, examination, evaluation, and presentation of dental evidence in criminal or civil legal proceedings in the interest of justice.<sup>12</sup> As there was less information regarding the utilization of forensic odontology findings in solving criminal cases in Tamil Nadu and Puducherry, this retrospective study was conducted using the case records.

A total of 2987 case records were used for this study which was referred to forensic sciences department by criminal courts the reason for this is only criminal courts have the authority to investigate the cases. Among these, 85% of the cases were referred to the Tamil Nadu forensic sciences department and 14.5% of cases were referred to Andhra Pradesh forensic sciences department and 0.5% to Puducherry forensic sciences department. The reason for the negligible amount of cases referred to the Puducherry forensic sciences department was that it was functioning for the last six months and before that, all cases were referred to Andhra Pradesh Forensic Sciences Department.

The reason why forensic odontological findings were not used was that cases were solved even without these findings. Serology, toxicology, blood alcohol, DNA testing, biology, impression evidence, image analysis was some of the other

findings utilized in crime investigation. Most of the cases were solved with the help of these investigations. Skull superimposition was the most commonly used method in the anthropology department, forensic sciences department. This method involves superimposing the post-mortem skull radiograph with the recent photo of the victim. The similarities between the radiograph and the photo were assessed and opinion was given if both were the same person. Only opinions were given and no definitive diagnosis was given.

On the other hand, the awareness regarding using forensic odontology findings in person identification was relatively less. The methods of bite mark analysis, lip print analysis and rugae pattern analysis were not known to the forensic scientist. There were no forensic odontologists in the forensic department. The necessary materials that were needed to record bite marks, rugae patterns were not available. Even though materials for recording lip prints were available, the database of lip prints was not available for comparison.

In western countries, a centralized system of record management (which includes medical and dental records) is followed. Also, forensic odontological opinions are obtained in all criminal investigations. Hence, retrieval of dental findings and the use of forensic odontological findings in crime investigation is very common. Whereas in developing countries like India dental records are neither maintained nor forensic odontologists are appointed in the Forensic sciences department.

## Conclusion

Forensic odontological findings were used very rarely in the investigation of the criminal case. Utilization of bite marks, rugae pattern, antemortem and post mortem records and lip prints in identifying criminal cases in Puducherry and Tamil Nadu is negligible. Training and workshops should be conducted regarding methods of bite mark analysis, lip print analysis, rugae pattern analysis among forensic scientists. It is recommended that qualified forensic dentists should be employed in the forensic sciences department and proper training should be given to forensic scientists. Also as the fingerprint database is maintained, the lip print database should be maintained for everyone.

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## Learning styles of undergraduate medical students – A cross sectional study using VARK questionnaire

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### Abstract

Learning is an individual's way of perceiving, processing and retaining new information. VARK (Visual, Aural, Reading/writing and Kinesthetic) is a tool for assessing learning style. VARK study helps in assessing learning preference of students and guide teachers to modify their teaching approach to enrich the domains of learning namely knowledge, skill, attitude and communication according to AETCOM, thus aiding implementation. To find out preferred learning style in the study population and to ascertain genderwise variation of preference. A cross-sectional prospective study in Department of Forensic & State Medicine, Medical College Kolkata was performed on 4th semester students over two months. All the students present in demonstration classes during data collection and gave their consent to take part in study were included. A pretested and validated VARK questionnaire (version 3) containing 13 questions were distributed among undergraduates. Data collected were evaluated according to proposed evaluation guideline dividing into 4 predominant groups namely 'V', 'A', 'R', 'K'. Total 192 students, (Male=116, Female=76), response rate 73%, aged between 19-25 years participated, among which females were 'R' and males 'K' predominant. Batch wise preference analysis showed on Monday and Friday batch was 'A' and other batches were 'K'. Kinesthetic was the most one all over, reading/writing being the second, auditory third and visual the fourth. Bimodal and trimodal responses were also found in few and 'RK' was most common. This study for implementation of competency based medical education (AETCOM) is first of its kind which is helpful to start new MBBS curriculum in a more effective approach.

### Keywords

Learning styles; Learning preference; Questionnaire; VARK; AETCOM; CBME curriculum

### Introduction

Learning style is an individual's way of perceiving, processing and retaining new information. The nature of any undergraduate and postgraduate learner depends on factors like age, sex, intelligence quotient (IQ), cultural status, level of mental preparedness, psychological back up, genetic and other factors which lead to differences in individual learning styles and outcome.<sup>1</sup> Students use different approaches to extract required information as their learning is influenced by learning atmosphere, curricular issues, academic infrastructure as well as teaching methods. So it becomes necessary for organizing the teaching methods according to the individual characteristics.<sup>2</sup> VARK questionnaire (Visual, Aural, Reading/ writing and Kinesthetic) is a simple, freely available, easy to administer and validated tool that encourages students to describe their behaviour in a manner of preference in learning styles. It was designed by Lincoln university of New Zealand in 1998. It is based on three basic principles i.e. a) Everyone can learn academic issues; otherwise everyone has their own styles. b) Learners' motivation is increased when different learning styles of

learners are taken into account. c) Educational concepts are learned through utilization of senses and different perceptions. In other words, students learn the education process by experience, projection, contemplation and accomplishment.<sup>3</sup>

VARK instrument divides students into four categories according to different preferences: Visual (a group of learners who learn best by observation and visual presentation, such as diagrams, pictures and figure etc. associated with clarification), Auditory or Aural (a group of learners who learn best through listening and verbal instructions), Reading/ writing (a group of learners who learn best by taking notes during lectures or reading written or printed texts) and Kinesthetic or practical (a group of learners who learn best by doing practical demonstrations, through gaining of experience and by manipulation of objects during a physical process).<sup>4</sup> Each style uses different part of the brain, namely occipital lobe for visual, temporal lobe for aural, cerebellum and motor cortex for physical movements, and cerebrum for cognitive functions. Although learners can use all of these modes of learning, one mode is often dominant and preferred.

Knowing the learning style in itself is not enough, it should be accompanied by implementation of those to give an impetus to the teaching learning process.<sup>5</sup> In today's era it has become essential to teach systematically to the undergraduates specially after the advent of AETCOM module (attitude, ethics and communication competencies) and new undergraduate curriculum prepared which focuses on creating “Indian Medical Graduates” possessing requisite knowledge, skills, attitudes, values and responsiveness. VARK study will not only

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help in assessing the learning preference of the students but also will guide the teachers to modify their teaching styles to enrich the domains of learning namely knowledge, skill, attitude and communication according to AETCOM.<sup>6</sup> Objectives of the study were to find out the preference of learning style in the medical students and to ascertain whether any preference in learning style exists between student groups gender wise.

## Materials and Methods

This was a cross sectional prospective questionnaire based study conducted on 262 students of 4th semester MBBS batch (2019) of Medical College, Kolkata in the Upgraded Department of Forensic and State Medicine. The duration of the study was 2 months. The study was conducted after obtaining approval from the institutional ethics committee. Predesigned, pretested and structured VARK questionnaire version 3.0 (closed type) containing 13 questions<sup>4</sup> was used as the study tool (Figure 1).

### Learning Questionnaire Study

Sex-

Age-

**1. You are about to give directions to a person who is standing with you. She is staying in a hotel in town and wants to visit your house later. She has a rental car. I would:**

- a. draw a map on paper  
b. tell her the directions  
c. write down the directions (without a map)  
d. collect her from the hotel in my car

**2. You are not sure whether a word should be spelled 'dependent' or 'dependant'. I would:**

- a. look it up in the dictionary.  
b. see the word in my mind and choose by the way it looks  
c. sound it out in my mind.  
d. write both versions down on paper and choose one.

**3. You have just received a copy of your itinerary for a world trip. This is of interest to a friend. I would:**

- a. phone her immediately and tell her about it.  
b. send her a copy of the printed itinerary.  
c. show her on a map of the world.  
d. share what I plan to do at each place I visit.

**4. You are going to cook something as a special treat for your family. I would:**

- a. cook something familiar without the need for instructions.  
b. thumb through the cookbook looking for ideas from the pictures.  
c. refer to a specific cookbook where there is a good recipe.

**5. A group of tourists has been assigned to you to find out about wildlife reserves or parks. I would:**

- a. drive them to a wildlife reserve or park.  
b. show them slides and photographs  
c. give them pamphlets or a book on wildlife reserves or parks.  
d. give them a talk on wildlife reserves or parks.

**6. You are about to purchase a new stereo. Other than price, what would most influence your decision?**

- a. the salesperson telling you what you want to know.  
b. reading the details about it.  
c. playing with the controls and listening to it.  
d. it looks really smart and fashionable.

**7. Recall a time in your life when you learned how to do something like playing a new board game. Try to avoid choosing a very physical skill, e.g. riding a bike. I learnt best by:**

- a. visual clues -- pictures, diagrams, charts  
b. written instructions.  
c. listening to somebody explaining it.  
d. doing it or trying it.

**8. You have an eye problem I would prefer the doctor to:**

- a. tell me what is wrong.  
b. show me a diagram of what is wrong.  
c. use a model to show me what is wrong.

**9. You are about to learn to use a new program on a computer. I would:**

- a. sit down at the keyboard and begin to experiment with the program's features.  
b. read the manual which comes with the program.  
c. telephone a friend and ask questions about it.

**10. You are staying in a hotel and have a rental car. You would like to visit friends whose address/location you do not know. I would like them to:**

- a. draw me a map on paper.  
b. tell me the directions.  
c. write down the directions (without a map).  
d. collect me from the hotel in their car.

**11. Apart from the price, what would most influence your decision to buy a particular textbook?:**

- a. I have used a copy before.  
b. a friend talking about it.  
c. quickly reading parts of it.  
d. the way it looks is appealing.

**12. A new movie has arrived in town. What would most influence your decision to go (or not go)?**

- a. I heard a radio review about it  
b. I read a review about it.  
c. I saw a preview of it.

**13. Do you prefer a lecturer or teacher who likes to use?:**

- a. a textbook, handouts, readings  
b. flow diagrams, charts, graphs.  
c. field trips, labs, practical sessions.  
d. discussion, guest speakers.

Figure 1: VARK questionnaire version 3.0

After informing in details about the purpose and all other details of the study and getting proper informed consent, the questionnaire was distributed among students in a single page printed format during practical classes from Monday to Friday of a week in five different batches. The consent form assured that denial of taking part in the study will not hamper the student's academic result and other curricular activities. All the students who were present and gave consent were included and those who were absent, did not consent were excluded from the study. Students were instructed to opt for the single best choice for each question. All the incompletely responded questionnaires and/or the one with multiple responses in single question were excluded from the study. The responded questions in each questionnaire were tabulated in MS Excel at first and then it was analyzed as per the proposed analyzing guideline provided along with the above mentioned questionnaire. The analysis was done based on (Figure 2) maximum number of Unimodal (V or A or R or K) response put by the students. If more than one mode was seen to be put in maximum number in response, it was scored as Multimodal preference (Bimodal= AV, AR etc. and Trimodal = AVR etc.). Chi-Square and other appropriate counting statistical test were applied to the data set using MS Excel software.

### Scoring Chart

Question	a category	b category	c category	d category
1	K	A	R	V
2	V	A	R	K
3	K	V	R	A
4	K	A	V	R
5	A	V	K	R
6	K	R	V	A
7	K	A	V	R
8	R	K	A	V
9	R	A	K	V
10	K	V	R	A
11	V	R	A	K
12	A	R	V	K
13	K	A	R	V
14	K	R	A	V
15	K	A	R	V
16	V	A	R	K

Count the number of each of the VARK letters you have circled to get your total score for each category.

Total number of V's circled =

Total number of A's circled =

Total number of R's circled =

Total number of K's circled =

Figure 2: VARK scoring chart

## Results

Among a total 262 students of 4<sup>th</sup> semester batch the age of the study participants ranged from 19-25 years in males and 19-22 years in females. The mean age of the entire study participants was 20.24±0.95 years with mean age of males and females was 20.29±1.06 years and 20.16±0.77 years respectively. The age distribution has been detailed in Table 1. After the VARK

scoring of the responded questionnaire by the students and analysis, unimodal preference was seen in 154 responders (80%) and 38 students (20%) showed multimodal preference (Table 2). The preference of learning preference was Kinesthetic (K) in most of the students, followed by Reading/writing (R), Auditory (A) and Visual (V) in decreasing frequency order (Table 3). Responders with multimodal preference showed more predominance to 'RK' followed by 'AK' followed by other bimodal and trimodal entities (Table 4). Gender distribution of the preference showed females

**Table 1:** Age distribution of the responders (students)

Age	19yrs	20yrs	21yrs	22yrs	25yrs	Total
Female	14	39	20	3	0	76
Male	23	53	29	9	2	116
Total	37	92	49	12	2	192

**Table 2:** Modality of preference among the students

Unimodal	Multimodal	Total
154	38	192
80%	20%	100%

**Table 3:** Details of unimodal learning style preference

Preference	Response	%
Kinesthetic (K)	59	31%
Reading / Writing (R)	42	22%
Auditory (A)	36	19%
Visual (V)	17	9%
TOTAL	154	80%

**Table 4:** Details of multimodal learning style preference

Preference	Response	Percentage
RK	13	7%
AK	06	3%
RV	04	2%
KV	04	2%
AR	03	1.5%
VR	03	1.5%
AV	03	1.5%
AVK	01	0.5%
KRA	01	0.5%
Total	38	19.5% (~ 20%)

**Table 5:** Genderwise distribution of learning style preference

Preference	Female	Male
K	19	40
R	23	19
A	14	22
V	6	11
RK	5	8
AK	3	3
RV	0	4
KV	2	2
AR	0	3
VR	1	2
AV	3	0
AVK	0	1
KRA	1	0
Total	77	115

**Table 6:** Batch wise distribution of learning preference

Preference	Monday	Tuesday	Wednesday	Thursday	Friday
K	8	17	12	14	8
R	9	10	7	9	7
A	11	4	7	4	11
V	5	5	-	4	4
RK	2	4	5	1	1
AK	1	1	2	1	1
RV	-	-	-	2	2
KV	2	1	-	1	-
AR	1	1	1	-	1
VR	-	-	-	-	-
AV	2	-	1	-	-
AVK	1	-	-	-	-
KRA	-	-	-	1	-
Total	42	43	35	37	35

were 'R' predominant and males 'K' predominant (Table 5). Batch wise preference analysis showed on Monday and Friday batch was 'A' and other batches were 'K' predominant (Table 6). No statistically significant association seen between gender and learning style preference in our study (p=0.14).

## Discussion

AETCOM which is a part of CBME has already been implemented in India. Indian medical curriculum for MBBS degree is of 5.5 years long. Till date there is no provision in any module or curriculum to assess the learning style of the students and yet on the other hand the AETCOM module for Indian medical graduates is greatly focusing on creating undergraduates with skill and knowledge by emphasizing more on student oriented educational approach. So for implementing the AETCOM curriculum effectively more importance should be given on the way a student learns.<sup>5,6</sup>

Various studies have been done on different types of learners but very limited studies are available on second year MBBS undergraduate students involving their learning style and preference.

In our present study, out of 262 students, 73% responded which is similar to a study in Saudi Arabia having response rate 70%.<sup>7</sup> The reason behind was due to the absentees, non-consenting and multiple/incompletely answering responders.

In present study 80% responders showed unimodal learning preferences and rest 20% had multimodal preferences. Kinesthetic (K) dominance was mostly seen in unimodal and among the multimodal RK (reading/writing and kinesthetic) was preferred over others. Distribution of students among unimodal and multimodal showed varied trends in different studies which adopted different methodology. A study conducted on MBBS students of a rural medical college in West Bengal, majority of students showed multimodal predominance in which AK (auditory, kinesthetic) was the most preferred style and in the unimodal group auditory was the dominant style.<sup>8</sup> Somewhat similar results were obtained in a study in Iran and Saudi Arabia.<sup>3,7</sup> Contrary to this, the studies on medical students in Central Kerala and urban medical college of West Bengal showed the majority to be unimodal learners in which auditory was the most preferred style.<sup>9</sup> A study in Puducherry reveals a bit of different result as visual to be the most dominant style among the unimodal learners.<sup>10</sup> Interestingly both auditory and kinesthetic were equally preferred as unimodal preference variant in a study in northern and central India.<sup>11</sup>

Gender wise preference for females and males was different in our study. Females were found to be more Reading and writing (R) dominant which is different from the study in Puducherry medical college where females were visual dominant.<sup>10</sup> Males were found to be kinesthetic (K) dominant which is at par with the study at Puducherry Medical College.<sup>10</sup> Absence of significant association between gender and learning style preference in our study ( $p=0.14$ ) signifies genderwise segregation during teaching is not needed for better learning impact. In the Iranian study the gender variation was statistically significant.<sup>3</sup>

The competency based medical curriculum and AETCOM

module has heightened the need for modified teaching styles to focus on the domains of learning and to assess the levels of competency which has further escalated the importance of VARK study. The rationale for this study was to assist the teachers in designing a lesson plan to address all students. Active learning strategies in contrast to traditional didactic lectures should be implemented by dividing the students into small groups based on their mode of learning.<sup>4,5,6</sup>

This study is based on means to perceive process and retain the information provided by any educational source. Though learning style and learning approach are not same exactly, it is useless to try to understand the learning approach of a student if the way they learn is not clear. Knowledge and implication of learning style of students can help a teacher to develop their pedagogical strategies. Active learning strategies are more rational as they consider different characteristics of learners.

With the advancement of time, the definition of knowledge has changed a lot as information are at our fingertips now. Knowledge acquisition and learning are more directed towards multimodal approach combining all the components of VARK. Even in this setting one particular mode is preferred over other within the mind of learner. In this study we mainly focused on finding the most preferred unimodal learning style among students by restricting multiple responses to a single question. The thought behind was to find out that preferred mode in the study population. Most of other studies incorporate multiple responses to a single question which reflects multimodal preponderance. The justification of the designer of VARK tool was initially to find the specific preferred mode for which questionnaire version 3.0 containing 13 questions was used as the study tool which is though all other studies used the latest version of VARK.<sup>4</sup> All the later versions concentrate more on finding multimodal trend of the responders.

Results from above studies suggest that the teachers must be well conversant with all the learning styles. The batch wise preference shows auditory and kinesthetic to be more dominant but despite this less attention is given to these two modes. This can be solved by modulating the teachers voice intensity and pitch for the auditory learners and also introducing role plays or case studies for kinesthetic learners.

Only 2nd year MBBS students (4<sup>th</sup> semester) were studied, hence this study has a limited scope of generalization. Inclusion of other confounding factors was beyond the scope of this study. Students from a single institute was used which might not represent whole student community, so extensive study is required. After the implementation of the new curricula, post-test questionnaire assessment will be beneficial to know the betterment in academic performance after adapting new teaching styles.

## Conclusions

Medical students' learning style has major implication on their quality of academics. An effective teacher must have knowledge of students learning style apart from pedagogical knowledge. Thus, narrower the gap between teacher intention and learner interpretation enhanced are opportunities to achieve desired outcome. Authors recommend for more impactful implementation of the new undergraduate medical curriculum with some recommendations such as more importance to small group discussion, necessary demonstration emphasizing unimodal learning preference. So assessment through VARK tool in the beginning of each academic year is highly recommended.

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## Assessing the knowledge about Consumer Protection Act and medical negligence in a medical college setting

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### Abstract

The doctor-patient relationship relies on mutual trust and conviction, but this trust, sacredness, and confidence, has become the talk of olden days, and now it sounds hollow. Some incidences cause suffering to the patients, forcing the legislature and the public to think twice about the credibility and authenticity of medical treatment given to the patients. In India, the Consumer Protection Act (CPA) of 1986 was enacted for better protection of the interests of consumer grievances. The current study was conducted to know awareness about CPA and medical negligence among faculty members in a private medical college & hospital. It was found that the awareness about CPA and medical negligence among the faculty was unsatisfactory. More than 65% of the participating faculties scored less than 50% in the questionnaire given to test their level of awareness, and only around 7% of the faculty could score 75% and above. The study calls for increasing awareness regarding various issues of the Consumer Protection Act among the medical fraternity.

### Keywords

Consumer Protection Act; Negligence; Awareness; Medical faculties

### Introduction

A doctor is given a place next to almighty God in our society.<sup>1</sup> The doctor-patient relationship relies on mutual trust and conviction.<sup>2</sup> The sole objective of a doctor is to improve the quality of life of the people and to mitigate sickness and suffering. The medical profession is not based on any mathematical laws, but it is a service-oriented, liberal profession, having a self-regulating code of ethics.<sup>3</sup> The relationship between doctor and patient is based on trust and confidence, but this trust, sacredness, and confidence, has become the talk of olden days, and now it sounds hollow. Some incidences cause suffering to the patients, forcing the legislature and the public to think twice about the credibility and authenticity of medical treatment is given to the patients.<sup>4</sup>

In India, the Consumer Protection Act (CPA) of 1986 was enacted for better protection of the interests of consumer grievances. This is done through quasi-judicial mechanisms set up at the district, state, and national levels. Consumers can file their complaints, which will be entertained by the quasi-judicial bodies referred to as consumer forums. These consumer forums have been empowered to award compensation to aggrieved consumers for the hardships they have endured.<sup>5</sup> The Act applies to all goods and services, excluding goods for resale or commercial purposes, services rendered free of charge, and

under a contract for personal service. After about a decade of its enactment, in 1995, the medical profession was also included within the ambit of CPA by the Supreme Court of India in a landmark case of Indian Medical Association vs. VP Shantha.<sup>6</sup> It is essential on the part of medical professionals to have adequate knowledge and awareness about CPA and its implication on their profession. The main aim of this study is to study and compare awareness about the Consumer Protection Act (CPA) and medical negligence among the faculty of the medical and surgical specialties.

### Material and Methods

The present study was conducted on 40 faculty members. (20 faculty members from medical specialties and 20 faculty members from surgical specialties). Written informed consent was obtained from the participants after providing them the information sheet that explained the purpose of the study. A self-administered questionnaire having 18 questions related to various aspects of the Consumer Protection Act (CPA) and medical negligence was provided to the participants. Prior permission to conduct the study was taken from the institutional Ethics Committee.

Each question had four options, out of which participant had to mark the most appropriate one. The participants were asked to respond to these 18 questions in half an hour, and once the participants replied to the queries, the questionnaires were taken back. For analysis, each correct answer is given score 'one,' and the wrong answer/un-attempted question is given score 'zero.' The individual scores were summed up to yield a total score. Scores were converted into percentage. Based on the marks secured, grading of faculty members was done as very low (<35%), low (35-50%), moderate (51-60%), good (61-75%), excellent (>75%).

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## Results

The awareness score of the faculty members of the surgical specialties was more (15% of faculty secured excellent & another 15% good grade) than the members of the medical specialties (5% of faculty secured good and no one secured excellent grade). (Table 1). A chi-square test was applied to study the association between the specialty and the marks secured. There is no significant association between the specialty and the marks secured (P value>0.05). This difference in awareness could be because surgical specialists encounter more medical negligence cases as compared to medical specialists. More than 65% of the participating faculty (overall) scored less than 50% in the questionnaire given to test their level of awareness, and only around 7% of the faculty (overall) could score 75% and above (Table 1). The questions related to medical negligence and their responses given by the faculty members are depicted in Table 2. Similarly, the questions related to the Consumer Protection Act and their responses given by the faculty members are depicted Table 3.

**Table 1:** Grading of faculty members as per marks secured

Specialty	Marks secured				
	<35% (very Poor)	35-50% (Poor)	51-60% (Moderate)	61-75% (Good)	>75% (Excellent)
Surgical	7(35%)	5(25%)	2(10%)	3(15%)	3(15%)
Medical	11(55%)	4(20%)	4(20%)	1(5%)	-
P-Value	0.225				

**Table 2:** Number of correct responses (N) to the questions on negligence by faculty members

Question	N
1. A patient got treatment from a Govt. hospital where no fee is charged. There is allegation of negligence against the treating doctor. The complainant can approach the a. Civil court & Consumer court    b. Civil court and Criminal court    c. Civil court only    d. Civil, Consumer and Criminal court	19
2. In a case of civil negligence against the doctor, on whom the onus of proof lies on a. Public Prosecutor    b. Doctor    c. Patient    d. Judicial Magistrate	15
3. Contributory Negligence is a defense in a. Civil negligence    b. Criminal negligence    c. Both a & b    d. None of the above	17
4. All the following are the defenses available for a doctor against allegation of negligence except a. No fees accepted    b. Res Judicata    c. Therapeutic Misadventure    d. Limitation period	25
5. A doctor while treating the patient without consent in an emergency is protected under a. Sec 90IPC    b. Sec 87IPC    c. Sec 89IPC    d. Sec 92IPC	9

**Table 3:** Number of correct responses (N) to the questions on CPA by faculty members

Question	N
1. When did the Supreme Court of India included medical services under the ambit of CPA? a. 1990    b. 1995    c. 1994    d. 1996	13
2. Consumer Protection Act (CPA) was passed by the Parliament in which year? a. 1987    b. 1986    c. 1985    d.1987	10
3. In CPA a complaint is to be filled within what duration from date on which a case of action has arisen. a. 2yrs    b. 1 yr    c. 3yrs    d. 4yrs	17
4. What is the time limit for appeal at various levels? a. 60days    b. 30days    c.90days    d. 120days	17
5. What is maximum time limit for giving justice to patient in CPA is? a. 100days    b. 90days    c. 150days    d. 200days	20
6. For false complaint under CPA, the complainant shall pay as penalty to opposite party, not exceeding rupees? a. 10,000    b. 50,000    c. 30,000    d. 60,000	22
7. Within how many days of admission date, district forum shall refer a copy of compliant to the opposite party? a. 30    b. 10    c. 40    d. 21	13
8. District Forum has same power as are vested in a Civil Court by a. II-Class Magistrate    b. I-Class Magistrate    c. Collector    d. Tahasildar	26
9. If a doctor fails to comply in a compensation case under CPA then punishment is in the form of a. Fine up to 10,000/-    b. Imprisonment    c. Both a & b    d. Fine up to 20,000/ -	30
10.The power of consumer courts are like a. Criminal Court    b. Civil Court    c. Both a & b    d. Special power	17
11.Which is not correct about Consumer Court? a. Decision within 3months    b. No advocate required    c. Court fees to be paid    d. Accused has to be present	9
12.State commission has the power to dispose off matters asking compensation amount a. 20lakh-1crore    b. Upto 20lakh    c. More than 1crore    d. None of the above	17
13.The Time limit to dispose off compensation cases at a level of District Forum is a. Within 2yrs.    b. Within 3 yrs.    c. Within 4 yrs.    d. Within 1yr	17

## Discussion

Medicine is a noble profession, but there is also growing anxiety both within the medical profession and in the community regarding increasing trends of complaints and lawsuits against doctors. Negligence in the medical world has assumed great importance with the medical malpractices suits in various countries in Asia, Europe, the USA, and more so in India. In the area of the patient-doctor relationship, two important models dominate viz. one is based on paternalism, and the other is founded on the doctrine of informed consent. According to Dworkin's standard definition of paternalism means interference with a person's liberty of action justified by reasons referring exclusively to the welfare, good, happiness, needs, interests or values of person coerced.<sup>7</sup>

In the present study, most of the participants were not aware of the Consumer Protection Act. The findings of our study are similar to the findings observed by Kachare et al.<sup>8</sup> A similar study by Anjaneyulu et al.<sup>9</sup> among medical professionals from Telangana state also showed the same findings. But in a study conducted in Indore among the Medical Professionals showed many doctors were aware of medical ethics and medical negligence.<sup>10</sup> In one more survey carried out on 120 faculty members from clinical departments of KIMS, Bhubaneswar, Orissa it was found that 82% of the participants were well aware to the facts that what makes a practitioner negligent in the view of the patients.<sup>11</sup>

The data in our study showed that detail knowledge regarding the aims and objectives of the Consumer Protection Act and its application is limited. Similarly, limited awareness was seen among the study by Jasuma et al.<sup>12</sup> But in a study carried out on 464 dental and medical specialists showed that awareness about CPA was higher among the medical professionals than dental professionals.<sup>13</sup> Due to the lack of updating knowledge by the professionals, there is an increased risk of malpractice, especially from complex case situations. Also, the expanding patient population is becoming more knowledgeable and aware of their rights, consequently taking action by contacting the consumer forum to lodge their complaints.

## Conclusion

The awareness level among the medical as well as surgical specialists in the present study was found to be very low, though the enactment of the COPRA Act 1986 was three decades old. Public awareness about CPA and medical negligence has increased in the last decade. Malpractice lawsuits have become a major concern in patient care. Lack of updating knowledge by professionals (medical and surgical), there is an increased risk of litigation, especially in cases with poor outcomes. It is recommended that doctors must update their understanding of the Consumer Protection Act and medical negligence to be legally safe. It is suggested to

organize intensive regular CME's and orientation programs to improve awareness and knowledge. This actually will help in the long term, the medical fraternity to develop and sustain confidence and mutual trust with the clients. It will create a positive, healthy atmosphere in medical practice. By this, the number of cases of disputes due to medical negligence will be reduced and reverse the increasing trend in our county.

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## Age, marital status and sexual offences: A “Law Triangle” for women in India

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### Abstract

The Indian legislature discriminates women based on age and marital status when quantum of punishment for sexual offences is in question. These two major factors frequently affect the criminalization of an accused by providing windows to escape in cases of sexual offences pertaining to marital relationship. The current ambiguities between the acts and Indian Penal Code in relation to age of consent, marital rape needs to be addressed at earliest. The paper outlines the revolutionary picture of changes in “Age of consent” and describes how multiple marriage acts contradict the content of S.375 IPC. It further argues on the role of the POCSO act with few conflicting verdicts in similar type of cases under the same. The paper reviews the legal aspects of marital rape and discusses how marital rape is still a “permitted offence” even after the recommendations of its deletion by the Justice Verma committee as well as United Nations. It also highlights the parliamentary debates on existence of marital rape. Recent changes in relation to S.375 and S.377 IPC in the context of marital rape are also discussed. It is high time India reconsider these laws that are still popular for their orthodox nature and contradictory content.

### Keywords

Age of a girl; Marital Rape; Sexual offences; Domestic Violence; Indian Laws

### Introduction

The Indian Legislature discriminates women based on age and marital status when the quantum of punishment for sexual offences is in question. These two major factors frequently affect the criminalization of an accused by providing windows to escape in cases of sexual offences in marital relationship. The roots of these affecting factors can be traced to the era of inception of Indian Penal code. This review basically focuses on divergent laws in India with special reference to S.375 of Indian Penal code (further will be cited as “IPC”), S.377 IPC, The Criminal Law (Amendment) Act 2013, The Hindu Marriage Act 1955, The Special Marriage Act 1954, The Child Marriage Restraint Act 1929, The Prohibition Of Child Marriage Act 2006, The Protection Of Children From Sexual Offences Act 2012 and The Protection Of Women From Domestic Violence Act 2005.

### 'Age of consent' and related amendments

Age of consent for sexual intercourse under “S.375 (5th clause) I.P.C.” and age mentioned in the “Exception to S.375, I.P.C” was 10 years in the initial version of Indian Penal Code. In 1891, Indian penal code was amended to revise the age of

consent from 10 years to 12 years and likewise the code defined “rape” as sexual intercourse with a married or unmarried girl (even with her consent) under 12 years of age.<sup>1</sup> The Age of consent act was applicable not only on unmarried girls but also on married girls ignoring the discrimination on the grounds of marriage. The law did not interfere directly with institution of child marriage in India, but only with premature consummation of it.<sup>2</sup> Since then, there remains a great controversy with respect to age of consent for sexual intercourse. Later on the age limit for “consensual sex” and “under the exception to sec.375 IPC” was changed to 14 years and 13 years respectively in 1925, 16 years and 15 years in 1940, and remained as such under the second last version of section 375 IPC in its 6<sup>th</sup> clause.<sup>3</sup> The same clause was later amended again and under the “criminal law amendment act, 2013” the age altered for two more years to turn out to be 18 years.<sup>4</sup> These incremental changes in the clauses of IPC S.375 reflect a logic that certain age for a girl should be regarded as immature to give consent for sexual intercourse.

### Marriage related acts and S.375 IPC – Connect and disconnect

Multiple acts are enforced to condemn and criminalize child marriages in India. Basically, all acts define certain boundaries in terms of age of bridegroom and bride as well as prescribe conditions for solemnization of marriages and cover other legal aspects of marriage. “The Hindu Marriage Act, 1955” and “The Special Marriage Act, 1954” prescribe the age 21 years for male and 18 years for female to get married.<sup>5,6</sup> Moreover, “The Child Marriage Restraint Act, 1929” which is an act to restrain the solemnisation of child marriages defines child is a person who,

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if a male, has not completed 21 years of age, and if a female, has not completed 18 of age.<sup>7</sup> However, as per “The Prohibition Of Child Marriage Act, 2006”, every child marriage, whether solemnised before or after the commencement of this Act, shall be “voidable” (and not “void”) at the option of the contracting party who was a child at the time of the marriage.<sup>8</sup> By definition, voidable marriage is a marriage that can be annulled or avoided (only) at the option of one or both the parties and it is different from void marriage, which is a marriage “*void ab initio*” or invalid from its very beginning. Nevertheless, (only) void marriage is considered as unlawful and requires no formality to terminate.<sup>9,10</sup> According to S.375 IPC, a man is said to commit rape if he did multiple sexual acts as prescribed in the section with a girl who is under 18 years of age even with her consent.

To sum up, a girl less than 18 years of age cannot give valid consent for sexual intercourse, a girl under 18 years even cannot marry a person legally under the aforesaid acts. But, the same section 375 could not be applied to a girl if she was a wife and a victim of marital rape even if under 18 years of age. Older version of IPC 375 under the exception reads as follows:

*“Sexual intercourse or sexual acts by a man with his own wife, the wife not being under 15 years of age, is not rape”*

Usage of the word “wife” in this section itself was contrary to the aforesaid acts and that might be because of the fact that child marriage in India is voidable and not *void ab initio*. United Nation’s Committee on the Rights of the Child under concluding observations on the combined third and fourth periodic reports of India, 2014 also recommended that in India all forms of sexual abuse of girls under 18 years of age including marital rape should be fully criminalized.<sup>11</sup> After waiting period of several decades, the amendment was introduced in October, 2017. Latest ruling published by Supreme Court of India amend the age under “exception to S.375 IPC” and reads as follows:

*“Sexual intercourse or sexual acts by a man with his own wife, the wife not being 18 years, is not rape”.*<sup>12</sup>

### The POCSO Act and its implementation

Until the arrival of the recent amendment, many articles and blogs raised their voices to condemn the law of the land and asked for justification in regards to exclusion of marital rape from the legal definition of “rape” with special reference to the age mentioned for the wife. The Indian Penal Code had failed to justify the discrimination of a girl on the basis of her marital status and her age with regards to marital rape. However, the provisions prescribed under The Protection of Children from Sexual Offences Act, 2012 were underrated in terms of its

applicability. “Aggravated penetrative sexual assault and punishment” clause reads down as follows:

*“(n) Whoever being a relative of the child through blood or adoption or marriage or guardianship or in foster care or having a domestic relationship with a parent of the child or who is living in the same or shared household with the child, commits penetrative sexual assault on such child”*

*“Whoever, commits aggravated penetrative sexual assault, shall be punished with rigorous imprisonment for a term which shall not be less than ten years but which may extend to imprisonment for life and shall also be liable to fine.”*<sup>13</sup>

The POCSO act defines a “child” as any person below the age of eighteen years.

Moreover, chapter V, Section 29 of The Criminal Law Amendment Act, 2013 under, “Amendments to The Protection Of Children From Sexual Offences Act, 2012” mentioned the following inclusion and substitution of section 42 of the POCSO Act which reads as follows:

*42. Alternate punishment: Where an act or omission constitutes an offence punishable under this Act and also under section 166A, 354A, 354B, 354C, 354D, 370, 370A, 375, 376, 376A, 376C, 376D, 376E or section 509 of the Indian Penal Code, then, notwithstanding anything contained in any law for the time being in force, the offender found guilty of such offence shall be liable to punishment under this Act or under the Indian Penal Code as provides for punishment which is greater in degree.*

*42A. Act not in derogation of any other law: The provisions of this Act shall be in addition to and not in derogation of the provisions of any other law for the time being in force and, in case of any inconsistency, the provisions of this Act shall have overriding effect on the provisions of any such law to the extent of the inconsistency.*<sup>4</sup>

Although the POCSO act does not cover child marriage specifically, but it automatically corrects the controversy of child marriage and marital rape as mentioned in aforesaid clauses. The girl, if married and if aged in between 15 to 18 years, who might not be protected under Indian Penal Code S.375, was very well protected under this act with justifiable punishment for the accused. The amendments in the act have further clarified the overriding status of this act in case of discrepancies in the laws. An organization named “Bachpan Bachao Andolan”, had filed a writ petition before Apex court to clear the conflict between the IPC and the POCSO Act.<sup>14</sup> Subsequently, as mentioned earlier, the age of “wife” has been altered from 15 years to 18 years under the exception to S.375 by the Apex court in 2017.

Nevertheless, an instance should be highlighted at this point which contradicts the provisions of the POCSO act. In a case of

State v. Suman Dass, The court acquitted a 22-year-old accused of charges of kidnapping and raping a 15 year old girl whom he later married.<sup>15</sup> Additional session's judge added,

*"I am afraid I am not impressed. The words "penetrative sexual assault" used in Section 3 of the POCSO Act goes to suggest that where physical relationship or sexual intercourse had taken place with consent of a girl child which is not derived by coercion or not in the nature of an assault or use of criminal force, or which is not resulting in exploitation, or where the consent is not obtained for unlawful purpose, no offence within the ambit of Section 3 of POCSO Act can be said to have been committed."* He further added, *"I am afraid, if that interpretation is allowed, it would mean that the human body of every individual under 18 years of age is the property of State and no individual below 18 years of age can be allowed to have the pleasures associated with once body"*

The court observed that consensual sex with a minor girl does not make an offence punishable under the POCSO act.<sup>16</sup> However, in another case, the Allahabad high court convicted the accused who was acquitted by an additional session judge on the ground of consent given by a minor girl for alleged kidnapping and sexual intercourse thereafter. The court added that her consent or willingness was meaningless as she was a minor at the time of the incident.<sup>17</sup> Same ways, the Punjab and Haryana high court had dismissed the plea filed by a man from Gurgaon district in opposition to his conviction for raping a minor girl and added that when the girl is below 16 years, the partner must be treated as a criminal and he couldn't plead that the act was consensual.<sup>18</sup>

Furthermore, utmost emphasis must be given to keep the care takers of these laws updated as in Ahmedabad, a deputy superintendent of police who had investigated the case of rape of a minor girl, was asked about the POCSO act during cross examination in a local court and he said that he did not know what was the POCSO act and when this act was introduced.<sup>19</sup>

### **Marital rape – A trivialized crime**

"Marital rape" the term itself is considered controversial by some scholars. But, the fact remains unchanged that marital rape is just an underreported crime provided law of the land consider it to be the one. Across the globe different countries have different laws for the cases encompassing marital rape. Unexpectedly very little consideration has been given to the issues of marital rape by researchers, counsellors and doctors.<sup>20</sup> If one compares the number of articles on marital rape with the number of articles on various other forms of violence against women, the ratio remains unjustified.<sup>21</sup> Few literatures on marital rape as compared to a hefty amount of literature on stranger rape may advocate that former is viewed as a less serious crime.<sup>22</sup> However, awareness regarding the necessity of

criminalization of this concept is gradually rising. Worldwide Statistics elaborates that women in particular relationship are usually the victims of the worst kind of physical abuse.<sup>23</sup> In India, the issue of marital rape always remains under highlighted in comparison to the other forms of domestic violence. The reason can be the loopholes in the legislations that do not validate criminalization of marital rape. According to National family health survey-3, 10% of married women reported to be forced physically for sexual intercourse and 5% reported to be suffering from other undesirable sexual acts.

Justice Verma committee, a committee appointed to reform anti-rape laws after the incident of Delhi gang rape, had cited multiple examples in relation to the legal status of marital rape globally and clearly mentioned that the immunity given to husband in regards to marital rape had already been withdrawn from major jurisdictions. Moreover, the committee had also stated that the changes in attitudes of public, police and prosecutors towards the perception of marital rape should accompany with the legal prohibition. The committee had recommended that the exception of marital rape given under IPC S.375 should be removed and further suggested that the law should specify that not only marital status but also any other type of relationship between the perpetrator and the complainant should no longer remain a valid defence or a justifying factor for lower punishment.<sup>24</sup>

Originally, the (then) central government had expressed urgency and brought down the new anti-rape law as an ordinance (Criminal Law Amendment Ordinance, 2013) which was later replaced by an Act. During discussion on anti-rape law in Lok Sabha, one of the (then) female Member of Parliament stated in favour of exclusion of marital rape from the ambit of rape-law with an argument that joint family system in India can sort out such incidences within family itself.<sup>25</sup> Despite the clear recommendations of Justice Verma committee, criminalization of marital rape was not able to find its place and exception to marital rape remains as such in amended version of S.375 IPC. Many noticeable movements in opposition to this ordinance were reported, but the central government was successful in passing the bill. Unexpectedly, the (then) strong opposition party also maintained strange silence. Since then, The Criminal Law (Amendment) Act, 2013 had been strongly criticized by multiple human rights and Women's Rights Organizations as well as academic scholars for its inadequate reflection of the Justice Verma committee's report. When asked by a member of Parliament with regards to planning of Government to criminalize marital rape, the (then) Minister of State for Home answered in the Rajya Sabha that the concept of marital rape, though considered and understood internationally, could not be suitably applied to India due to the factors related to education, poverty, religious beliefs and present mindset of society to treat marriage as sacred.<sup>26</sup> Furthermore, Minister also

cited the 172<sup>nd</sup> report on review of rape laws submitted by Law commission in 2000 which was also against the deletion of exception under IPC 375 with an argument “*deletion of the same may amount to excessive interference in marital relationship.*”<sup>27</sup>

### The PWDVA act – A Civil alternate to the criminalization of Marital Rape

Failure of government to give justice on marital rape cases, Indian courts have occasionally attempted to give some relief to the victims of marital rape by applying domestic violence laws or IPC S.498A whenever applicable. “The Protection of Women from Domestic Violence Act, 2005” is an act that came into force to protect the rights of women guaranteed under the Constitution. According to this act under CHAPTER II, definition of domestic violence reads as follows:

“Harms or injures or endangers the health, safety, life, limb or wellbeing, whether mental or physical, of the aggrieved person or tends to do so and includes causing physical abuse, **sexual abuse**, verbal and emotional abuse and economic abuse”

With following explanation to define sexual abuse

“Sexual abuse’ includes any conduct of a sexual nature that abuses, humiliates, degrades or otherwise violates the dignity of woman”<sup>28</sup>

Under the purview of this act, magistrate, if finds the case fit under PWDVA, can pass orders like protection orders, residence orders, monetary relief, custody orders, compensation orders for the applicant along with penalties prescribed for accused on breaching the orders. The punishment for breaching the orders is imprisonment up to one year or fine up to 20,000/- or both. It is also to be noted here that Maintenance provisions prescribed under various personal laws may stand contrary to the provisions prescribed under PWDVA 2005.<sup>29</sup>

Fundamentally, this act can serve civil purpose only and cannot criminalise the accused of marital rape with justifiable punishment. Though the act includes and defines sexual abuse separately, but fails to rationalize punishment for the same as it basically focuses on relief for the victims and not on the criminalization of the accused. Virtually, the Act serves equal punishment for economic or verbal abuse of wife similar to that of her sexual abuse. No doubt, procedures under PWDVA hasten the process in giving “Civil” justice to the victims of marital rape, permanent solution except divorce is still to be searched for. Furthermore, it is to be noted that in western countries, where marital rape is already criminalized, many of the cases are ended with divorce only even after successful prosecution of husbands by their wives.<sup>30</sup>

As far as implementation of this act is concerned, it is the responsibility of the state to appoint protection officers to carry

out duties as prescribed under PWDVA. Extreme disparity can be observed in numbers of Protection officers appointed i.e. Maharashtra has appointed 3730 Protection officers in comparison to Gujrat, Bihar, Tamil Nadu and west Bengal where numbers of Protection officers appointed ranges from 20 to 40 only.<sup>31</sup> This may hamper proper implementation of the act and need special attention as soon as possible.

### Marital rape and Newer vs Earlier S.377 IPC

Older S.377 IPC which deals with unnatural sexual offences reads as follows:

“Whoever voluntarily has carnal intercourse against the order of nature with **any man, woman** or animal, shall be punished with imprisonment for life, or with imprisonment of either description for a term which may extend to ten years, and shall also be liable to fine. Explanation— Penetration is sufficient to constitute the carnal intercourse necessary to the offence described in this section.”

Now, this section was also applicable on husband performing unnatural sexual acts irrespective of consent of his wife. Apex court pointed out following lines in regards to S.377 IPC.<sup>32</sup>

“It is relevant to mention here that Section 377 IPC does not criminalize a particular people or identity or orientation. It merely identifies certain acts, which if committed, would constitute an offence. Such prohibition regulates sexual conduct regardless of gender identity and orientation,”

However, on 6th September 2018 in its landmark judgement by Apex court, a five judge constitution bench decriminalized S.377 IPC.<sup>33</sup> Special emphases was given to “consent” of the partner irrespective of gender or the act. Consensual anal intercourse no longer remains an offence. The judgement also narrates the discrepancies between S.375 and S.377 as follows,

“Section 377, so far as it criminalises carnal intercourse between heterosexuals is legally unsustainable in its present form for the simple reason that Section 375 IPC clearly stipulates that carnal intercourse between a man and a woman with the wilful and informed consent of the woman does not amount to rape and is not penal.”

Now, S.375 IPC in its amended version describes penetration by penis into mouth, urethra, vagina or anus of a woman to constitute the offence termed as “rape” and “exception-2” of the same section reads as “sexual intercourse or sexual acts by a man with his own wife.....” no-where defines “order of nature” separately. The words “sexual acts” is a vague term and may incorporate “anal or oral intercourse” within its subjective interpretations and in that way unnatural sexual acts may also fall under exception to S.375 IPC which already allows a married man to commit “rape” on his wife (without consent apparently). So, there is still a conflict between S.375 and S.377

IPC in regards to whether “sexual acts” under exception includes unnatural sex or not, because definition of “rape” includes both. Reflections of these inconsistencies can be observed in many court cases as points for defence. However, verdicts made in Allahabad High Court in case of Sanjeev Gupta vs Ritu Gupta, Kerala High Court in Bini T. John v. Saji Kuruvila and Karnataka High Court in Grace Jayamani v. E.P. Peter clearly state that sex against the order of the nature as well as against the wishes of a woman or wife or anybody is not only a criminal offence but also a marital wrong and amounts to cruelty as well as a ground for dissolution of marriage.

To conclude, age of a girl and marital status of her should no longer remain as weapons of the defence in cases of sexual assaults within marriages. Loopholes in the laws must be approached at the earliest so that they cannot provide windows for escape. It is high time for inclusion of marital rape within the purview of existing laws with justifiable punishments instead of considering it just a form of domestic violence.

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## CASE REPORT

# The challenges of forensic medical expertise in aircraft accidents: A case report

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### Abstract

One of the crucial roles that a Forensic Pathologist performs is disaster victim identification. Aircraft accidents are one of the common scenarios that cause mass fatalities. Most of the aircraft crashes happen right after take-off or before landing. Aircraft crashes typically result in multiple casualties due to massive mechanical injuries. We describe a case of identification of 5 deceased passengers of a sports plane that crashed immediately after taking off. One of the passengers managed to jump off the plane before crashing. Visual identification was not possible in the case of four out of the five passengers that remained in the plane as they suffered from superficial charring. The passenger that managed to jump off was found 30 meters away from the wreckage, and identification was possible in his case due to preservation of facial features, dentition, and fingerprints. Autopsy and visual examination were performed on the five cadavers, and blood samples for toxicological analysis and DNA profiling were preserved. Alcohol was not present in the blood of any of the deceased. Full DNA profiles of the cadavers were generated, and the identities of them were established to be members of the Parachute club.

### Keywords

Disaster victim identification; Forensic Anthropology; Aircraft crash; DNA profiling

### Introduction

Aircraft accidents with a large number of victims pose a particular challenge to the forensic medical expertise. Among numerous dilemmas that forensic examiners face with, the identification of victims, recording of injuries and potential pathological conditions, determining the cause of death and toxicology results are crucial issues. In some cases, such information can elucidate the cause and sequence of the accident. The reasons for plane accidents are diverse and might include pilot's incompetence or operational error, sudden health condition or intoxication of the pilot, mechanical factors or, most commonly, the combination thereof. Disaster victim identification is one of the crucial roles of a Forensic Pathologist in cases of aircraft accidents. We describe a case of identification of 5 deceased passengers of a sports plane that crashed immediately after taking off.

### Case report

Five people died when a sports plane, Cessna 128 crashed in recreational airport near Banja Luka in May 2012. The victims include five skydivers, the members of this sports club. The plane crashed to the ground immediately due to the take-off

problems, whereby one person managed to jump off the plane and four passengers remained inside the plane. The incident happened in front of the numerous spectators. At the scene of accident, four charred bodies were found in burnt plane wreckage, whereas one body was located some 30m far from the crash site. Extremely high temperature resulted in melting of particular metal parts of plane wreckage. The body of a young male person wearing a greenish *skydiver's overall* was found near the wreckage, away from the fire area, and was labeled No.1. The victim had an empty parachute backpack fastened to his back and the crinkled opened parachute (removed by the emergency medicine team) was found in the immediate vicinity of the body. Aside from visible mechanical injuries the body revealed fully preserved morphological features thus enabling visual identification as well as the identification according to fingerprints or dental status. The remaining four bodies (labeled 2, 3, 4, and 5) found in burnt plane wreckage revealed charred superficial tissues, which made any kind of visual identification impossible (Figure 1).



**Figure 1:** One of charred bodies. Note the metal handle of ripcord in the left hand.

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Upon investigating the scene of accident, the mortal remains were packed into the plastic body bags and transported to the forensic medical morgue. On the following day, visual examination and autopsy of the remains was performed to determine the condition of the bodies, type and distribution of injuries and blood samples for toxicological analysis and DNA identification were collected. On almost completely charred cadaver labeled with No.2, skin section in the region of the left shoulder blade was preserved revealing clearly visible blue tattoo in the shape of a girl with spread wings. Characteristics of the tattoo along with the presumptive identity of skydivers were useful for the identification of the body. In other charred cadavers, there were no preserved individual features that might be used for identification. The charring was particularly pronounced in facial region including almost entire jaws (except for individual partly preserved molars). Massive mechanical injuries of the head and/or thoracic organs (brain injuries, lacerations of the aorta, lungs and heart) were identified as immediate cause of death in all victims. The death was instantaneous, thus, signs of pre-mortem fire exposure were not identified. The bruises in the region of fracture and laceration-contusion wounds indicated that the wounds have occurred pre-mortem. At autopsy, biological samples for DNA analysis were collected (blood from preserved deep vessels and femoral bone fragment as a secondary sample) as well as blood samples for alcoholemia test and further toxicological analysis. The analysis revealed presence of alcohol in neither of victims. The identity of charred bodies was successfully confirmed using the method of DNA identification (DNA extraction, QiaAmp Mini kit; PCR reaction, PowerPlex ESX 16). The identity of five young males in the age of twenties, members of Parachute Club was confirmed.

## Discussion

In most cases, plane crashes are accidental; however, possible sabotage or homicide-suicidal events are to be taken into consideration. Nevertheless, the majority of accidents occur at plane take-off or landing. For a medico-legal expert, the scene of an aircraft accident is of crucial importance, i.e., the site of plane or wreckage crash, the position of the victims or their remains. Before being moved, the bodies must be properly labeled and photographed, and then individually packed into the body bags and delivered to forensic laboratory along with personal belongings detected near the body and which can be of help in identifying the victim<sup>1</sup>.

The autopsy of a dead body or remains of the pilot is only one, yet highly important step in the investigation process. This procedure provides information about the injuries observed on pilot's body and possible history of underlying diseases, which along with the results of toxicological screen (alcohol,

medication, drugs) contributes to elucidating the cause of the accident. Checking of pilot's medical records prior to accident might indicate potential causes of sudden health episode that might have been associated with the loss of capacity. The examination of pilot's hands and feet can reveal soft tissue laceration and bone fractures, which result from striking the fixed structures of the aircraft controls (control surface injuries).<sup>1,2</sup> In that respect, radiological examination can prove useful.<sup>2</sup> Such injuries are not specific for the pilot only and may have high incidences in passengers, thus requiring highly cautious interpretation and drawing of conclusions.<sup>3</sup> Tissue remains on the parts of aircraft controls mechanism could be of importance in the DNA identification of the pilot.<sup>4</sup>

Toxicological analysis of pilot's blood is of paramount importance for the identification of possible cause of plane crash. Relevant biological samples include blood, urine, CSF, bile, gastric content, stroma, as well as liver, kidney, spleen, brain, lung and muscle tissues. Besides the pilot, the autopsy should include all other deceased crew members and passengers in order to improve accident reconstruction, evaluate the safety equipment provided for passengers' use and to provide necessary evidence to a multitude of medico-legal problems, both civil and criminal, that inevitably arise after a fatal accident.<sup>5</sup>

Fatal aircraft accidents involving large number of casualties reveal uniform injury pattern in all victims, commonly massive mechanical injuries induced by decelerate forces. A decline from such injury pattern in any of passengers might suggest the action of some specifically different force such as explosive device. Suspected fire in a cabin can be confirmed or excluded in a toxicological analysis and determination of the blood level of *carboxyhemoglobin in the victims*. The cause of death in plane crash victims found in water can include submersion or hypothermia due to prolonged period in cold water.<sup>6</sup> High speed and extreme decelerate forces at the moment when plane hits the ground often cause decomposition and fragmentation of the body, which makes the examination of mortal remains particularly difficult.<sup>7</sup> In such instances, identification of the bodies is crucial, followed by collecting relevant samples for toxicological analysis. The degree of body decomposition often does not allow visual identification of the victims. Dental and fingerprint identification are much more effective and reliable provided that medical records on victims' dental status are available<sup>8,9</sup> and that hands are preserved (non-charred bodies). Tattoos, scars or other body marks could also be of help in the process of identification. Finally, DNA identification is the most superior method in conditions of heavily injured and mostly decomposed tissues.

The bodies of victims after the crash of small-planes are commonly in a better condition as compared with the accidents of commercial planes; however, in this case, four of five bodies

revealed complete or almost complete charring of superficial tissue, especially in the region of head and teeth, hands and feet. Such cadaver condition did not allow the *identification using classical recognition methods such as dental status of fingerprints. Thus, the DNA analysis has been performed and the identity of the victims was successfully confirmed. Alcohol intoxication of the pilot has been excluded as a potential cause of plane crash, so the responsible Prosecutor's Office did not require any further toxicological analysis. Similarly, to the common injury pattern in fatal aircraft accidents, polytrauma in all victims included laceration-contusion wounds in the lungs and liver, ruptures of thoracic aorta, serial fractures of the ribs, skull and pelvic bones as well as upper and lower limb bones. The investigation of this accident is still in progress and the actual cause of the crash has not yet been established.*

### Conclusion

In cases when the *condition of the remains does not allow the identification using classical recognition methods, i.e., dental or fingerprint data, the DNA analysis is the most superior identification method. Reliable identification requires minimum amounts of preserved tissue such as blood from deep blood vessels or bone tissues that were not exposed to extreme temperatures.*

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## CASE REPORT

# Bite mark analysis: A case report

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### Abstract

Bite mark analysis is the most difficult, frequently used technique in forensic dentistry. Bite marks can be found on both victim and assaulter. Many violent assaults consist of more than one bite, making them difficult to identify. Bite mark will appear as circular or oval or U shaped arches. Description of this bite pattern vary in each case, and there is a time dependent changes seen on the skin. Human bite mark tends to differ from person to person hence this made it as a valuable tool for identification in many violence cases. The number of concordant features in this case suggested that there was a high degree of probability that the bite marks on the right arm of the victim was caused by suspect. In the present case, the suspect was identified by the bite inflicted on him in defence by the victim.

### Keywords

Bite mark; sexual assault; child abuse

### Introduction

Forensic odontology is the study of dental applications in legal proceedings. This covers a wide variety of topics including individual identification, mass identification, and bite mark analysis. Forensic odontology is one of the most unexplored and intriguing branches of forensic sciences. In the last half century, it is separated to a specialty. Teeth are often used as weapons when one person attacks another or when a victim tries to ward off an assailant. Sweet (1995) in his view states that no two human bite marks can be identical.<sup>1</sup> Mc Donald has defined bite mark as "a mark made by the teeth either alone or in combination with other mouth parts".<sup>2</sup> Bitemarks are classified as 'crush' injuries where each tooth compresses the skin and soft tissues and leaves indentations and or breaks in the skin. Bite marks are usually seen in cases involving sexual assault, murder, and child abuse and also recovered from scenes of theft. Most common site is on the face mainly lip, ear, nose followed by upper extremity in females, bites on males are commonly seen on arm and shoulders. The first person who published an analysis of bite mark case is Sorup, he called this method as odontoscopy.<sup>3</sup> Even though using bite mark evidence began around 1870, the first published account involving a conviction based on bite marks as evidence was in the case of Doyle V. State, which happened in Texas in 1954<sup>4</sup> and followed by most famous case of 20<sup>th</sup> century involved serial murderer

Ted Bundy who killed at least 100 women. The most complex challenge in forensic dentistry is the recognising, collecting and analysing the bite mark.<sup>5</sup>

According to the National Crime Records Bureau (NCRB), Rape is the fourth most common crime against women in India. In India large number of cases go unreported, the willingness to report the case has increased in recent years. Rape cases significantly increased from 18,359 to 22,172 during 2005-2010. Rape causes not only physical torture to the body of the women victims, but also to her mental, psychological, emotional to suffer from the phase of shame, fear of being dishonoured from the society. The national capital Delhi state has explosion in rape cases followed by Madhya Pradesh, Rajasthan. In southern region Andaman and Nicobar island, Pondicherry, and Lakshadweep states have higher significant increase rate of rape case from 7.3%, 1.1%, 0.0% to 10.7%, 2.4%, 5.13%.<sup>6</sup> Pondicherry is a city situated in the union territory of Puducherry, population of Pondicherry is around 7,54,000 as of now.

Human bite marks are found when the teeth are used as weapons. Though the person's teeth may look the same but they are different in size, shape arrangement, wear and tear damage with age. Bite mark analysis is the most difficult contentious work undertaken by forensic odontologist. In the administration of justice, bite mark analysis may be used as an evidence in the judicial system. This case of sexual assault wherein bitemarks were used as additional evidence leading to conviction is reported.

### Case report

The case was that of a 20-year-old girl was allegedly raped and assaulted by a 25-year-old male in the year of 2013 September.

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The girl was not able to recognise things and she was mentally disturbed and there was no other eye witness on this incident. The victim of the bite-mark (male) and the suspect (girl) were examined after 5 days of the crime. The case was registered with CBCID, Puducherry, bearing Crime No. 01/2013 dated 28/12/2012. The victim was examined by a team of forensic odontologists from Government Dental College and Hospital, Puducherry at the Puducherry Central Prison, on the request by the police.

On examination of the victim (male) semi-circular pattern of 6 bitemarks of the teeth were seen in the right arm (Figure 1) and 6 bitemarks were identified in the left arm (Figure 2).



Figure 1: Bitemarks present on the right arm



Figure 2: Bitemarks identified on the left arm

Life size photographs of the bitemarks were taken. In the photograph of the bitemark on the left arm, the teeth indentations were not prominent probably due to a time delay of 5 days in recording the bitemark. So, the bitemark in relation to left arm of male could not be analysed, impression of the bitemark on the right arms of the male were made by addition silicon light body impression material with a baking of plaster of paris for suitable support of the impression. The impression was washed and dried up they were poured in dental stone to produce the positive replica of the teeth for bitemark analysis. The dental examination and bite registration on modelling wax were done for both the victim and the suspect. Then, dental impressions were made to generate dental casts for bitemark analysis (Figure 3).

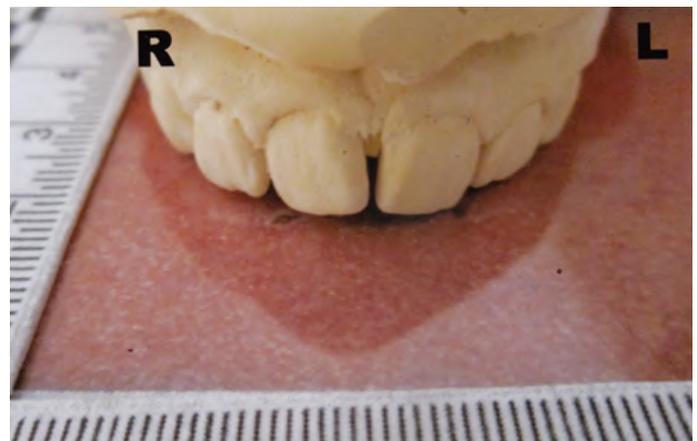


Figure 3: Dental impressions made to generate dental casts for bitemark analysis

### Analysis of the bitemark

#### (A) Bite mark analysis using models

On comparing dental casts of girl with the bitemark on model casts obtained from right arm of the male by hand docking method (Table 1)

Table 1: Comparing dental casts of girl with the bitemark on model casts obtained from right arm of the male by hand docking method

Method	ABFO Scoring	
	Manual method	Possible match
Photocopy method	Probable match	2
Computed assisted method	Probable match	2

(1) The shape of upper (maxillary) arch was semi-circular and the distance between the two prominent indentations of bitemark on the outer (lateral) side of right arm was 1.8 cm. The shape of lower (mandibular) arch was semi-circular and the distance between two prominent indentations of bitemark in relation to inner (medial) side right arm was 1.6 cm. As per ABFO scoring

guidelines, the degree of correspondence for shape of the arches was scored as 2 (1 for upper jaw and 1 for lower jaw).

(2) The teeth represented in the bitemark of right arm of male as prominent indentations were upper central incisors along the outer (lateral) side of right arm and lower right central incisor, lower right lateral incisor and right canine along the inner (medial) side of right arm. These teeth represented in the bite mark are present in the dental model of the girl. As per ABFO scoring guidelines, the correspondence for representation of teeth in the bitemark and teeth present for the girl was scored as 2.

(3) The two prominent bitemark indentations along the outer (lateral) side of right arm of male corresponds to outer (distal) edges of upper central incisor teeth of the girl. The two prominent bitemark indentations along the inner (medial) side right arm of male corresponds to outer (disto-incisal) angle of lower right central incisor and cusp tip of lower right canine. As per ABFO scoring guidelines, the degree of correlation of bitemark indentations with tooth position in the dental model of girl was scored as 2.

(4) The spacing between upper central incisor teeth of the girl is not identifiable in bitemark pattern on model casts obtained from right arm of the male.

(5) As upper central incisor teeth of the girl are rotated the outer edges of these two teeth has caused prominent indentations along outer (lateral) side of right arm. Also the distance between the outer edges of these prominent indentations (1.8cm) corresponds to the total width of upper central incisor teeth (1.9 cm). The two prominent bitemark indentations along the inner (medial) side right arm of male correspond with the arch form of lower jaw teeth. As per ABFO scoring guidelines, the correspondence for tooth marks in the bite with the shape of the upper and lower arches was scored as 2.

**(B) Bitemark analysis from life sized photographs of bitemarks**

On bitemark analysis from life sized photographs of bitemarks on the right arm by overlay method (Table 2)

**Table 2:** Matching of overlays obtained from dental cast of girl to the photograph of bitemark of male

Method	ABFO Scoring	
Manual method	Possible match	1
Photocopy method	Probable match	1
Computed assisted method	Probable match	2

(1) Spacing of bitemark indentations seen on outer (lateral) side of right arm of male corresponds to spacing between teeth 11 and 21, with ABFO scoring of 1.

(2) Widths of teeth as measured from bitemark indentations in the photograph of the right arm of male, and widths of the incisal edges of the teeth as measured from dental models of girl are shown in Table 3.

**Table 3:** Comparison of width of teeth in the photograph of the right arm of male, and width of the incisal edges of the teeth in dental models of girl

Teeth (as per FDI)	Width of teeth in photograph	Width of the incisal edges in dental model
11	7.0 mm	7.0 mm
12	6.0 mm	6.25 mm
21	7.0 mm	7.5 mm
41	4.5 mm	5.0 mm
42	5.0 mm	5.2 mm
43	7.0 mm	6.45 mm

The widths of teeth 11, teeth 12 and teeth 42 of girl corresponds to width measured from bitemark indentations of the same tooth on right arm of male. ABFO scoring for correspondence of tooth size, curvature of arches and shape of individual teeth in the bitemark with dental model of girl was 4. The other distinctive features evident from photographs of bitemarks of right arm and overlays are rotation (mesiolabial) of teeth 11 and labially (forwardly) placed teeth 42. ABFO scoring for these distinctive features was 2.

**Discussion**

Forensic odontology which is also called forensic dentistry or bitemark evidence expertise mainly involves the identification of an assailant by comparing a record of their dentition with a record of a bite mark left on a victim. Bite mark comparison is fairly new. Police investigators have always noticed that at some crime scenes, criminals seem to leave their bite on food products, chewing gum, cheese, chocolate or more commonly on the skin of their victims, especially in cases of rape, child abuse, and homicide. Depending upon the type of victim, some bitemarks last for hours and others for days, but almost all bitemarks alter themselves as time elapses. Bite mark analysis guidelines are the result of a collective effort of the participants of the bitemark workshop of the American Board of Forensic Odontology assembled in Anaheim, California, February 18th through 20th, 1984. Careful use of these guidelines in any bitemark analysis will enhance the quality of the investigation and conclusion. Studies have been performed in an attempt to find the simplest, most efficient, and most reliable way of analyzing bite marks. Factors that may affect the accuracy of bite mark identification include time-dependent changes of the

bite mark on living bodies, damage on soft tissue, poor photography, impressions or measurement of dentition characteristics.<sup>8</sup>

Several methods of bite mark analysis have been reported. All these involves 3 steps, registration of both the bite mark and the suspect dentition, comparison of dentition and bite mark, evaluation of the points of similarity and dissimilarity.<sup>9</sup> When analysing a bite mark, important step is to compare dental features between a subjects dentition and the bite injury.<sup>10</sup> Registration of the bite mark by photography is used in all cases, photographs are then enlarged to life size proportion of comparison followed by impression of bite indentations are made and they are used to reproduce models which can then be used for comparison. Comparison of this bite can be done by direct or indirect method. In direct method, use of a model of the suspect teeth which is compared to life size photograph of the bite mark. In indirect method, it involves the transparent overlays and computer based comparison technique. Most used individual characteristics are tooth morphology width, thickness, rotation, labiolingual position, arch width, arch shape inter tooth, and missing teeth.<sup>11,12</sup> In the present case spacing of bite mark indentations seen on outer side of right arm of male corresponds to spacing between 11 and 21. There was a mesiolabial rotation of teeth 11 and labially placed 42, ABFO scoring for these distinctive features was 2. Width measured from bite mark indentations of the same tooth on right arm of male. ABFO scoring for corresponding tooth size, curvature of arches and shape of individual teeth in the bite mark with dental model of girl was 4. The width of teeth 11, 12, 42 of girl corresponded with the width of teeth as measured from bite mark indentations in the photograph of the right arm was in accordance with dental model of the suspect. The color of the bite mark was mainly red, dark brown in some photographs and in some it was of lighter shade, size of the bite mark measured approximately 1x2 cm, shape of the of the upper arch was 'U' shaped.

In this case, the comparison shows that there is a concordance in terms of general alignment of the bite mark caused by the maxillary incisor teeth of suspects dental cast with the bite marks visible on image. Bite mark on the right arm shows some degree of specificity to the suspect's teeth by virtue of few concordant points. Thus, the teeth of the victim probably caused the bite marks on the right arm of the suspect. In the present case, the suspect was identified by the bite inflicted on him in defense by the victim. When this evidence was placed before the jury during trial, the jury incorporated this bitemark analysis as additional evidence from the forensic odontology perspective and justice was rendered to the victim.

## Conclusions

Bite mark analysis is important aspect in forensic dentistry, it is new and potentially valuable. Bite mark can be recorded in sexual offence, child abuse cases and the analysis is mainly based on individuality of a dentition which is used to match a bite mark to a suspect. Bite mark evidence have played a role in judicial system and hence this is a valuable tool for identification in many criminal cases.

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## CASE REPORT

# Situs Inversus Totalis: An incidental finding in a fatal case of road traffic accident

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### Abstract

Human body is externally symmetrical but internally asymmetrical due to genetic makeup. The genetic mutation to the genes responsible for the reversal of handed asymmetry causes the condition called situs inversus. The incidence of situs inversus is 1 in 10000 to 1 in 50000 birth.<sup>1</sup> Situs inversus is most of the time an incidental finding during investigation for some other problem, otherwise, they live a normal healthy life. In some cases, few complications are seen frequently with situs inversus eg: congenital heart disease (like ASD, VSD etc), Kartagener syndrome, infertility etc. Situs inversus sometimes produces difficulties in making diagnosis. Situs inversus also open negligence cases against doctors due to misdiagnosis of some disease conditions like acute appendicitis, cholecystitis etc. or non-information of cases of situs inversus during taking consent of any procedure or surgery. We encountered a case of situs inversus totalis as an incidental finding during postmortem examination in NBMCH Darjeeling.

### Keywords

Situs ambiguous; Situs Inversus Partialis; Situs Solitus; Situs inversus totalis

## Introduction

Human body is externally bilaterally symmetrical or mirror image of opposite side. But handed asymmetry is seen internally, which is anatomical differences in left and right side of body. It can be seen with example: apex of heart is directed to left and base is directed to right, stomach present in left, liver in right. This normal internal asymmetry is called Situs Solitus.<sup>2</sup>

When this handed asymmetry/ Situs Solitus gets reversed the condition called Situs inversus and Situs Ambiguus.<sup>2</sup> According to position of thoracic and abdominal organs the human body could be Situs Solitus (normal internal asymmetry), Situs Ambiguous (also known as heterotaxy means reversal of some organ but not others) and Situs Inversus totalis (complete reversal of all thoracic and abdominal organs).<sup>3</sup> Situs Inversus Partialis (partial anomaly in abdomen or thorax).<sup>2,3</sup> The incidence of situs inversus is low i.e. one per ten thousand to fifty thousand per life birth.<sup>1</sup> Most of them remains asymptomatic throughout their life and incidentally found when they investigated for any other diseases.<sup>4</sup>

We incidentally found a case of situs inversus totalis during postmortem examination in NBMCH Darjeeling.

## Case Report

A 38 year male was sent for post mortem examination in mortuary of North Bengal Medical College & Hospital, Darjeeling by Matigara Police Station. As per the history provided by the police and relatives, deceased was asymptomatic until he met with a road traffic accident. He was shifted to Department of General Surgery in unconscious condition, where on examination and investigation, he was diagnosed with diffuse subdural and subarachnoid hemorrhage, laceration of anterior abdominal wall in left iliac fossa with peritoneal bulging and healthy abdominal organs. Deceased received abdominal stitches with peritoneal repositioning under aseptic and antiseptic precautions. The subdural and subarachnoid hemorrhage was treated conservatively. Deceased condition didn't improve and finally succumbed within 24 hour after road traffic accident. The body was shifted to NBMCH mortuary for postmortem examination to establish cause of death.

### Postmortem examination findings

A 38 year old, 169 cm in length, 59 kg weight, and well-nourished Hindu male body was wrapped in white hospital clothes. The following injuries were observed on external examination; ½" x 2 ½" oval, red coloured grazed abrasion present over the left side of face, 3 ½" long surgically stitched wound over the left fronto-parietal region of scalp, and 2 ½" long surgically stitched wound parallel to left inguinal canal on the left iliac fossa. On internal examination; a contusion measuring 5 ½" X 6" was present on the left fronto-parietal region corresponding to the surgically stitched wound, thin layer of diffuse subdural and subarachnoid hemorrhage was present over both cerebral hemispheres with congested and

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edematous brain matter. On dissection of the thorax; heart was situated in retro sternum with apex directed to right. It weighed 165 gm, and without any abnormalities. Valves were normal with patent coronary vessels. Both the lungs were congested with two lobes present in right lung and three lobes present in left lobe. On dissection of abdomen; greater curvature of the stomach was present in the right side, liver and gall bladder was predominantly present in left hypochondria, spleen was present in right upper quadrant of abdomen, appendix along with cecum was present in left iliac fossa, and right kidney was slightly above as compare to left kidney. We opined that the deceased died due to subdural and subarachnoid hemorrhage sustained as a result of blunt force trauma of head. Situs Inversus Totalis was an incidental finding in the case.

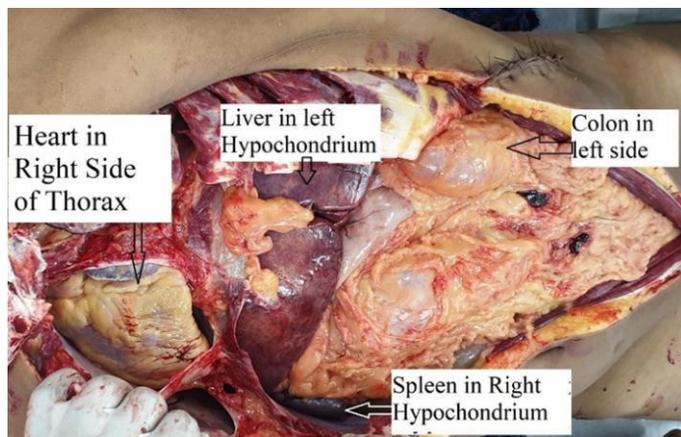


Figure 1: Thoracic and upper abdominal organs on dissection

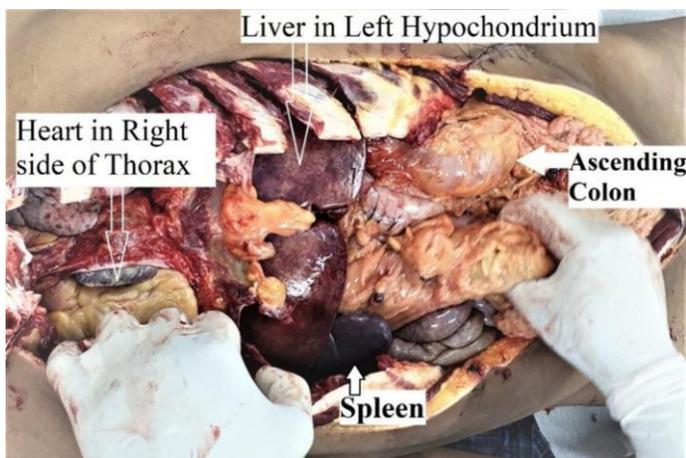


Figure 2: Abdominal organs on dissection

## Discussion

Situs Inversus Totalis is an anatomical congenital anomaly with low incidence i.e. 1 in 10000 life birth.<sup>1</sup> This condition results in mirror image of thoracic and abdominal organ. Normally the human body is externally symmetrical but internally

asymmetrical due to genetic makeup. The internal asymmetry is because of formation of major body axes in fetus during formation of primitive streaks in 3rd intrauterine week.<sup>5</sup> The major body axis consists of the cranial-caudal axis, dorsal-ventral axis, the medial-lateral axis, and the left-right axis.<sup>5</sup> The major body axis is established with the formation of primitive streaks in 3rd IUL in the stage of gastrulation.

### *Development of Heart:*<sup>6,7</sup>

In period of gastrulation heart is the first organ come in function from the 21st day of IUL. Heart develop from cardiac primordium. Through cardiac primordium two lateral endocardial tube forms which further fuses to form primary heart tube. The primary heart tube further elongates and bend to right and form C shaped structure. These conformational changes result in right outer curvature formed by ventral surface of primary heart tube and dorsal side of heart tube forms the left inner curvature of C shaped heart. Further elongation of at both arterial and venous end, heart converted in S shaped. The primitive atrium acquires a more dorsal and cranial position. The end result of cardiac looping is to bring the four presumptive chambers of the future heart into their correct spatial relationship to each other.

### *Development of Alimentary canal:*<sup>8,9</sup>

By the end of 5th week foregut divides into pharynx, thoracic esophagus, abdominal esophagus, stomach, and proximal half of duodenum. At the start of fourth week, stomach development begins with slight expansion of foregut which during 5th week further differentiate into greater and lesser curvature due to differential growth of dorsal and ventral wall of fusiform shaped stomach. During the seventh and eighth weeks, after 90° rotation of developing stomach around cranio-caudal axis results in left sided greater curvature and right sided lesser curvature. Liver starts developing from hepatic plate (in ventral side of duodenum), proliferation of cells in hepatic plate form hepatic diverticulum then in hepatoblast (liver primordial cells). Gallbladder and cystic duct develop from cystic diverticulum (in ventral side of duodenum caudal to base of hepatic diverticulum). When the stomach rotates to the left and the liver shifts into the right side of the peritoneal cavity. Pancreas develop from dorsal (form head, body and tail of the pancreas) and ventral pancreatic bud (form uncinuate process and bile duct). Both dorsal and ventral pancreatic bud fuse to form definite pancreas.

Spleen develops from mesenchymal condensation in dorsal mesogastrum of lesser sac. Spleen does not develop from gut tube. Rotation of the stomach and growth of the dorsal mesogastrum translocate the spleen to the left side of the abdominal cavity. By the fifth week, presumptive ilium grows more rapidly than abdominal cavity so loop of midgut is thrown into a yolk sac as a fold called the primary intestinal loop.

Cranial limb of loop forms ileum and caudal limb will form ascending and transverse colon. At the apex primary intestinal loop is attached to umbilicus by vitelline duct. By the sixth week due to increased growth of abdominal organ (particularly liver) primary intestinal loop herniate into umbilicus with 900 counter clock rotation. Up to tenth week intestinal loop grow and form jejunal-ileal loops, cecum and appendix. By the end of tenth week and eleventh week, retraction of primary intestinal loop complete with additional 1800 counter clock rotation. After complete 2700 counter clock rotation, cecum comes inferior to liver and proximal hindgut pulled downward and formed the ascending colon.

According to position of thoracic and abdominal organs the human body could be Situs Solitus, Situs Ambiguous (also known as heterotaxy means reversal of some organ but not others) and Situs Inversus totalis (complete reversal of all thoracic and abdominal organs).<sup>2</sup> Situs Inversus Partialis (partial anomaly in abdomen or thorax).<sup>2, 3</sup> Anatomical difference between Situs Solitus and Situs inversus totalis are depicted in Figure 3.

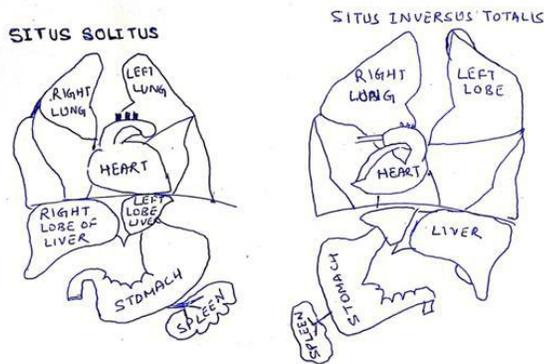


Figure 3: Anatomical difference between Situs Solitus and Situs inversus totalis

Anomalies associated with situs inversus include; congenital heart disease such as atrial septal defects, ventricular septal defects, transposition of great vessels, absent coronary sinus, double outlet right ventricle, total pulmonary anomalous venous defect and pulmonary valve stenosis,<sup>10</sup> and Kartagener Syndrome,<sup>11</sup> Situs inversus with levocardia is rare, and it is almost always associated with congenital heart disease.<sup>12</sup>

Recent studies suggests that left-right asymmetry defects might be due to genetic abnormalities in lefty genes, nodal genes, and ZIC 3, ACVR2B and Pitx2 genes and mutation of these genes are present on chromosome 12.<sup>13</sup> There are mainly four theories which explain the formation of visceral transposition.<sup>13</sup>

- All organs transposition theory believes that the position disordering of progenitors of viscera during embryo period causes visceral transposition.

- Uneven heat theory believes local high temperature of embryo leads to the inversion of organs.

- Twins theory is based on observing the frequency of visceral transposition among twins.

- Embryo rotation highlights the rotation of embryo during development leads to the anomaly.

From medicolegal point of view, Situs Inversus Totalis may be a cause for incorrect diagnosis and may results in wrong treatment. Medical negligence may be alleged in such cases, and hence, when in doubt, the doctor should investigate to exclude situs inversus. When a patient diagnosed situs inversus along with other disease condition is planned for any surgery or investigation an informed consent must be taken after informing about the disease condition and also about situs inversus.

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**PERSPECTIVE**

# DM in Clinical and Forensic Toxicology: A blueprint

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## Introduction

Currently in India, there is a great need of specialists in toxicology who can look after not only clinical aspects but also the legal aspects. Recent rise in deaths due to environmental toxins, incidents of vitriolage, wildlife poisonings, suicidal and homicidal poisonings, industrial and occupational poisonings, etc. have highlighted the need for specialists still more. In many such cases, perpetrators go scot free, mostly because the treating physicians are not aware of how to report such cases to the authorities and still more, how best to collect evidence to achieve successful prosecution. In view of this, a need for starting a super specialty course of DM in Clinical and Forensic Toxicology stands justified. The aim of the proposed DM course would be to prepare a trained workforce in clinical and forensic toxicology, with the highest skill levels. In light of the above, a detailed perspective of the course is being presented here.

## Prerequisite qualifications

Prerequisite qualification for the proposed DM course will be an MD in forensic medicine from a recognized institution. If necessary, there can be an entrance written test, followed by an interview.

## Course duration

The course duration will be of 2 years, divided into 4 semesters of 6 months each. From the first semester itself, the trainee should be posted in the hospital in different departments. A proposal in this regard is shown in Table 1.

## Course content

Besides the usual topics taught at the undergraduate and postgraduate levels, there should be emphasis on application of basic and clinical sciences in toxicology, as shown in Table 2. The DM students would be required to publish at least 4 papers in journals having an impact factor (JIF). They should be

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**Table 1:** Schedule and duration of the trainee pursuing DM in clinical and forensic toxicology

Department	Duration	Purpose
Casualty	3 months	To prepare MLCs in cases of poisoning and institute scientific treatment
Medicine	3 months	To learn general principles of management
ICU	3 months	To be able to manage poisoning cases needing acute and emergency care
Radiology	3 months	To understand and assimilate the application of radiology in toxicology, such as detection of radiolucent drugs
Pathology	3 months	To understand the basics of pathological toxicology. The trainee must be able to recognize histopathological slides and understand the relevant changes caused by different poisons
Forensic science laboratory	3 months	To be able to understand the actual working of analytical toxicology, e.g. how to run a GC or an HPLC equipment.
Pediatrics	3 months	To be able to understand common poisonings in children, and their management
Obstetrics and Gynecology	2 months	To understand and manage poisoning during pregnancy; cases of illegal abortions caused by poisonous drugs
Psychiatry	1 month	To understand psychiatric Issues in the Critically Poisoned Patient

**Table 2:** Areas of emphasis in the proposed course

1. Chemical terrorism	8. Identification of venomous animals
2. Doping in sports	9. Identification of poisonous plants
3. Drug dependence and abuse	10. Industrial & occupational poisoning
4. Drug facilitated crimes	11. Pediatric toxicology
5. Environmental toxicology	12. Pharmaceutical toxicology
6. General principles of toxicity testing	13. Target organ toxicology
7. Geriatric toxicology	14. Wildlife poisonings

encouraged to attend and actively participate in conferences and workshops dedicated to toxicology. Stress should be on actual hands-on training.

## Degree awarded

After the successful completion of the course, a DM degree in clinical and forensic toxicology will be awarded. An honorary DM degree to all examiners of the first batch may be awarded in order to avoid any legal problem. This is the norm in all parts of the world before starting a new course

## Conclusion

It is pertinent to note that currently forensic medicine is *probably the only specialty which does not offer any DM super*

*specialty course.* All para clinical subjects except for Forensic Medicine and Toxicology offer DM courses (DM Clinical Pharmacology after MD pharmacology; DM Clinical Immunology and DM Virology after MD microbiology; DM Clinical hematology and DM Immunology after MD pathology). Even preclinical courses like physiology and biochemistry are offering DM courses. Starting a DM course in Clinical and Forensic Toxicology would not only produce a

trained workforce in clinical and forensic toxicology, but also add much needed respect to this specialty. The proposals put in here are author's views towards the need and development of toxicology, that has long been ignored. The details can be brought to the notice of the concerned authorities for necessary approvals before starting the proposed course. The proposed blueprint can be further modified and elaborated by the institutions at the time of initiation of the course.

## Advances in firearm serial number restoration

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Gun violence and other criminal activities involving firearms have been on a constant rise over the past few decades. As more and more complex yet precise methods continue being researched for ascertaining the manner and modus operandi of such crimes, certain simpler evidences cannot be overlooked for the purpose of identification. Often, firearms and ammunitions are present as the primary evidence pertaining to crimes involving armed violence. The firearm is a trove of evidences, which can be used to ascertain the identity of the weapon as well as that of the perpetrator. The methods commonly used to identify use of a firearm include and are not limited to study of the rifling pattern, measurements involving Vernier calipers, GSR analysis, injuries sustained as a result of firing, ascertaining the range, trajectory and velocity of firing, and, through the analysis of firing pin, breech, chamber and other such markings left on the ammunition<sup>1</sup>. Serial number markings engraved on the firearm constitute one of the earliest form of evidences that facilitate easy and swift identification. Nations like the United States, were amongst the first countries worldwide, to mandate the stamping of serial numbers on all manufactured firearms in order to aid investigative processes.<sup>2</sup>

Over the years, different obliterative procedures have emerged with the intent to hinder investigation and identification. These methods include etching, electro-discharge machining (EDM), casting, filing/grinding, peening, drilling, welding, centre-punching and over-stamping. These obliterative methods target the underlying crystalline structure, which had previously undergone deformation during the marking process. Since the initial deformation extends well below the level of the observed indentation, it harbours certain evidence which may be exploited for the purpose of restoration. Different restorative processes permit visualization of the marked serial numbers via targeted reformation of this original deformity.

Chemical and electrolytic methods constitute some of the oldest methods used for restoration of obliterated serial numbers. The process of restoration using chemical reagents is a three-step process, that includes, polishing the surface, treatment with alloy specific etchants under regulated conditions of

temperature and time, and followed by, visualization under low-power magnification. This orthodox method still remains as good a restorative method as any of the newer techniques. Amongst the various etchants currently in use, Frye's reagent remains the oldest and most commonly used. Its use on iron and steel surfaces for the purpose of restoration dates back to as early as 1940. Over the years several reagents have been developed for use on different surfaces such as aluminium, steel and brass. Electro-etching methods act via selective dissolution of the metal surface to reveal desired characteristics. It employs a variable DC voltage source, a cotton dipped in an electrolytic solution (Davis reagent, Turner's reagent, Ferric Chloride etc.) behaving as the cathode, and the specimen, behaving as the anode. This completes the electrochemical cell and causes restoration. These chemical and electrolytic etching methods target the underlying metal resulting in dissolution of the surface via oxidation. The various reagents currently in use have reported complete restoration of the obliterated serial markings on both ferrous and non-ferrous surfaces with more or less equal potency.

The 1950s and 1960s marked the advent of the ultrasonic cavitation method. Ultrasonic cavitation brings about etching by formation of vapour bubbles resulting from a localised reduction in pressure. Unlike chemical etchants, cavitation results in complete restoration on all metallic surfaces with equal vigour. The duration required for restoration ranged between a minimum of one minute with Zinc alloys to a maximum of 30 minutes when working with alloy steel.

The next method to be employed for restorative purposes was magnetic particle inspection. MPI enables visualization of the serial number by magnetizing the test specimen. The magnetized surface is then sprayed with finely divided magnetic particles which migrate to the site of disturbance. Developments involving alternate light sources have rendered improved visualization by coating the magnetic particles with fluorescent chemicals followed by viewing under UV light. Despite it being a highly effective and non-destructive method, it is not preferred, owing to the high cost and space consumption.

By the 1950s, the FBI had started their own series of experiments with serial number restoration. One of the methods successfully developed by them include heat restoration. This encompasses applying heat onto the specimen surface in order to visualize the obliterated mark. Heat restoration proved to be much more efficient resulting in 100% restoration when compared to the other methods developed by the FBI such as

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frost method, radiographic examination, liquid penetrant method and electroplating.

In 2015, obliterated serial numbers were successfully restored using Electron Backscatter detection. EBSD measures the atomic structure in the near-surface region of the specimen in question. Electron diffraction pattern is collected at each beam position and crystallographic orientation of the pattern is determined. This aids in analysing the underlying obliterated mark<sup>3</sup>. Recent developments for the purpose of restoration target visualization of the obliterated mark at the cost of minimum damage to the surface in question. Although newer techniques continue being researched and developed, chemical etching continues to remain the most exploited method.

While serial number restoration can help overcome the problem of identification, it is only as effective as the nature and condition of the firearm in question. In nations like India, with its abundance of country made firearms, stamping of serial

numbers might not always been seen through till the end. In such cases additional evidences or makings, such as proof marks may be relied on. In the absence of any such evidences, the expert will have to fall back on the commonly used indicators such as rifling and other firing marks. However, for most purposes, restoration of serial numbers, obliterated as well as concealed, remains an effective means of identification.

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# FORENSIC MEDICON – 2020

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