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From Editor's Desk

Dear All,

I give my sincere thanks to my editorial team who had been supporting me in my endeavour of bringing up JIAFM volume 44. After initial hiccups and hitches, now the first two issues of JIAFM volume 44 is published and is available on the website. There have been changes in the editorial office after May 2022 and we were running late due to covid, causing the postponement of the conference, and the election, resulting in delayed taking over the charge of the editorial board and new governing council. I am thankful to **Dr. Siddhartha Das our Joint Editor,** who had been with me in all my thoughts and deeds.

All the manuscripts had undergone a double-blinded review process; grammar and plagiarism check (wherever required), and separately the reference check. We responded to all the queries of the authors in our new official email ID of the editorial team - editorjiafm2022@gmail.com. I am thankful to all the authors for keeping their patience and feel sorry, as sometimes I may not have responded to their calls or messages due to varied reasons, but the editorial team had been very vigilant and serious in responding to all the emails received. We had a long pending manuscripts and we are publishing the articles on a first come first basis, but sometimes due to delay in the response given by either reviewers or the author themselves, the article loses its place. Hence, it would have taken some time to respond accordingly.

I need to especially thank our **reviewers,** without whom we would not have come up with a quality issue as was desired. The name of reviewers who supported us, in this issue, had been added in the journal. As far as possible, the overall comments given were constructive and detailed. They marked and inserted their suggestions as comments on the manuscript file or made changes in the manuscript using the track changes option. They supported with sufficient reasons and detailed suggestions for the authors so that they could improvise, revise or resubmit their work accordingly.

Almost 10 manuscripts were rejected after suggestions and comments by reviewers, due either to, the subject matter being under quality, out of the scope of the journal or many times, lack of corrections as suggested by the reviewers on time.

I thank **Dr. Mandar Sane; Dr. Narendra Patel** & **Dr. Vivek Chouksey** as Associate editors; **Dr. Richa Nigam** as Statistical and Lauguage Editor; and **Mr. Chain Singh Lodhi** as technical editor, for bringing up Ist issue of volume 44 well on time.

Sincerely

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Editorial

Forensic Histopathology - Transforming the Bane to Boon?

Prof. (Dr.) C B Jani

Forensic Pathology is the branch of medicine that applies the principles and knowledge of the medical sciences to many legal issues within the field of law. The medical examiner is responsible for determining the cause and manner of death, identifying the deceased if unknown, determining the approximate time of death and injury, collecting evidence from the body that can be used to prove or disprove an individual's guilt or innocence and to confirm or deny the account of how the death occurred, documenting the injuries or lack of them, deducing how the injuries occurred, documenting any natural disease present, determining or excluding other contributory or causative factors of death, issuing the death certificate, and documenting all these events through an official autopsy report.[1]

The above mentioned tasks specifically require analytical back up, more commonly in form of Forensic Histopathology and Forensic Toxicology. Forensic Toxicology including analytical Toxicology has advanced with major contributions of Forensic Scientists. Probably, that is not the case with Forensic Histopathology at least with Indian context.

My personal experience permits me to write that the application of histopathology in autopsy cases began with cases of "Obscure autopsy" where in naked eye findings were not sufficient to opine cause of death and usually they were "Organs preserved: Opinion reserved" sort of cases. But, since last two decades, here in India, Autopsy Surgeons/Forensic Pathologists have started expanding the scope beyond such cases and it was adopted to confirm or support naked eye findings in organs. To quote none else but myself, under guidance of my post graduate teacher and Head-Prof.(Dr) B D Gupta sir, we endeavoured a research project in this area.[2] On change of my place of work, more or less similar research project was again undertaken, of course after 5 years duration of first project.[3] The second project was at altogether a different tertiary care centre with different samples. Briefly, conclusions of both those projects can be summarised as under with reference to indication/s for Histopathology Examination (HPE):

1) To know cause of death;
2) To confirm cause of death;
3) To know delayed histopathological changes &
4) To confirm/exclude pregnancy.

On the basis of fruitful deductions of both studies, it can be safely concluded that histopathological examination in medicolegal autopsy work is a boon, provided it is rational, technically self-sufficient and interpreted in broader perspectives. Quality control, quality assurance and audit in histopathological examination can make it more scientific and near accurate.

Very interestingly, a new dimension was explored to this field by studying "Pattern of histopathological changes of liver in poisoning".[4] At occasions, negative chemical analysis reports in poisoning cases lead to "negative autopsy" and pose hindrances in such death related issues including insurance claims. So, it is high time to contemplate whether histopathology in poisoning cases can be of help as "supplement", if not "substitute"?

Though little different from autopsy work, we under took a research project based on histology of seeds of forensic importance (common ones).[5] Can we think of submitting some portion of stomach contents for histopathology and microscopically to identify such poisons of vegetable origin, as organic irritant poisons are difficult to be detected at FSL?

Over and above to role of Forensic Histopathology in sudden deaths and trauma, few more indications or areas have also been documented in recent biomedical literature[6], i.e. decomposition changes, age estimation from organ histology, age estimation from histology of bones, maternal deaths, poisoning deaths etc., with emphasis on histopathological changes in various conditions-physiological or pathological.

It is obvious that Forensic Histopathology needs to be practised on larger and wider aspects than present, which shall have "objective evidence" based autopsy opinion, even though as "Supplement". Few schools of different thought suggesting to avoid this practice mainly because of lack of proper training for sampling and interpretation, since at majority of autopsy centres, the Forensic Medicine department either didn't have infrastructure and trained medical and paramedical staff or so called "Forensic Histopathology" laboratory are not serving purpose other than complying to erstwhile MCI or NMC requirements.

With same spirit, Department of Forensic Medicine & Toxicology– AIIMS, Bhopal had organised "India's First Ever Hands on Workshop on Forensic Histopathology" in February, 2020 for 3days – the integral part was practical training on techniques for grossing, sampling, preservation, processing and staining process, of course to ensure that any opinion in which Histopathology has been articulated stands scientific in terms of interpretation and expression.

It is high time for all concerned to start expanding "Forensic Histopathology" work practically and make it a Boon (rather than Bane!) to Forensic Pathology. To begin with, we can think of various research projects where, autopsy samples are subjected to microscopy, which will validate such data and in turn, have sound impact further on its admissibility in further investigation and positively improve entire medicolegal investigation with firm scientific basis.

Selected Readings:

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ORIGINAL ARTICLE

Profile of Alleged Sexual Offences in Jhalawar Region of Rajasthan: A 2 Year Retrospective Study

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Abstract :

The present retrospective study was done with the aim to analyze the pattern of alleged sexual assault cases that were reported to the hospital during 1st Jan 2019 - 31st Dec 2020. Of the total cases of sexual assault involving both female and male survivors were included in this study. We found that a total of 287 cases reported to emergency of Jhalawar Medical College & S.R.G. Hospital, Jhalawar, Rajasthan, with history of sexual assault with given informed consent for their medico-legal examination. The most commonly affected were 11-20 years of age group (62.36%) and 42.16% of the victims were students. Majority of victims were unmarried (66.20%) and most of victims belonged to low socioeconomic status. In 73.86% cases, the perpetrator was unknown/stranger to victims. Only few cases (7.66%) were reported within 12 hours and (11.50%) between 12-24 hours for medical examination. Injuries found on the genitals includes 86.75% old torn and 9% fresh torn hymen injury, 3.5% cases have injuries like abrasion, bruises and laceration while extra-genital/body injuries were in only very few cases (3.2%).

Keywords : Sexual assault; Demographic profiles; Victim-perpetrator relation; Medico-legal examination.

Introduction :

Sexual offence & assault has been an unfortunate and tragic misshapen in our society since ages. Lately, the incidence of sexual assault cases has been increasing heavily with each passing years. WHO defines sexual violence as "Any sexual act, attempt to obtain a sexual act, unwanted sexual comments/advances and an act directed against a person's sexuality, using coercion, threat of harm or physical force by any person regardless of relationship to victim on any setting including but not limited to home or work."[1]

By definition (The Criminal Law Amendment Act, 2013), A man is said to commit "rape" if he a) penetrates his penis to any extent, into the vagina, mouth, urethra or anus of a woman; or b) insert any object or part of body except penis into the vagina, anus or urethra of a woman; or c) manipulates any part of woman's body, so as to cause penetration into the vagina, anus, urethra or mouth of such woman; or d) applies his mouth to the vagina, anus or urethra; or makes her do so with him or any other person, under circumstances of following description as 1) Against her will 2) without her consent 3) with her consent when her consent has been obtained by putting either her or any other person in whom she is interested in fear of death or of hurt 4) with her consent, when at the time of giving such consent, under unsoundness of mind or intoxication or by administration of drugs or stupefying agent, she is unable to understand the nature and consequences of that to which she gives consent 5) with or without her consent when she is under the age of 18 years 6) when she is unable to communicate consent 7) with her consent, when man knows that he is not her husband and her consent is given because she believes that it's her husband. The "Will" and "consent" are different. Every act done against the will of a person is done without his consent, but an act done without the consent of a person is not necessarily against her will.[2,3,4]

The material facts to be considered are the conduct and behavior of the victim. It is not a rape where a woman initially objects, but subsequently gives her consent to sexual act. Rape can occur without causing any injury, and as such negative evidence does not exclude rape.[5]

Globally, Sexual offence and assaults are one of the important causes for physical and mental trauma, even leading to mortality. There can be various types of sexual offence such as Rape, Incest and Adultery (classified as natural offence), Sodomy/anal intercourse, buccal coitus (unnatural offence) and others like stalking, sexual harassment, trafficking, indecent assault, pederasty/paedophilia etc. Although, No reason can be justified as such, for heinous act of sexual assault by a person, but distress due to someone's egoistic clashes or to take revenge on someone due to any means, refusal or failure in romantic affairs or conflict with intimate partner or in marriage or dear ones, unwanted sex agreed due to pleading, blackmailing, threats or tricks, disturbed emotional & mental status & frustration, even simply ill thoughts in person's nature can be common reasons for sexual assault.

If we form an opinion based on facts globally, different studies show that one in every five women have suffered an attempted rape or rape by an inmate or acquainted partners. Sexual assaults

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are most likely to occur when a victim and offender are known to each other and are likely to have had a prior relationship as family members, intimates or acquaintances. One major fallacy regarding victim–perpetrator relationships is that of "stranger-rape" occurring most likely. In India, the reported cases represent only a tip of iceberg. Many cases go unnoticed either due to their dignity and reputation in the society. The victims feel the society looks at them in a different way if they come to know that she has been sexually assaulted, so victims continue to perceive Sexual victimization as a private matter. As a registered medical practitioner, one have the moral and legal duty to the country to help in administration of justice by proving medical evidences and scientific interpretation of medical findings by an early and detailed medical examination of vital importance to prevent loss of important trace evidence.[1,6]

According to the National Crime Records bureau (NCRB), rape or sexual assault cases India have increased exponentially, the highest being from Rajasthan, Uttar pradesh, Madhya pradesh & Maharashtra in year 2019 & likewise, highest being cases from Madhya pradesh, Rajasthan, Uttar pradesh & Maharashtra in year 2018 in cases of offender known to victim and unknown to victim. In view of, rape on women and girls both adults and minor age groups, Rajasthan, Uttar pradesh, Madhya pradesh and Maharashtra being highest cases in year 2018-2019.[7,8]

The act of rape has a profound impact on the physical and mental health of the victim and is associated with an increased risk of a range of sexual and reproductive health problems, with both immediate and long-term consequences. Many victims suffer from psychiatric problems, some commit suicide or suffer from venereal disease along with unwanted pregnancy and rape trauma syndrome. Injury pattern and assault characteristics may also differ according to victim-perpetrator relationship and other various factors & circumstances of each case. The offence against women are dealt within the law in various sections of Indian Penal Code (IPC), Criminal Procedure Code (Cr PC), Indian Evidence Act (IEA), The Protection of Women from Domestic Violence Act, The Protection of Children from Sexual Offence Act 2012 etc. In cases of sexual assaults, various tests for detection of semen, saliva and blood are to be conducted to prove or disprove the allegation.[9,10,11]

This study is to understand the pattern and profile of sexual assaults in Southern East region of Rajasthan. Epidemiological study of this nature will act as useful planning tool for government authorities and regulatory bodies to plan, upgrade and execute strategies towards prevention of sexual offence.

Materials and Methods :

This descriptive, observational & retrospective study is to be conducted in Department of Forensic Medicine of Jhalawar medical college Jhalawar, compiled of hospital case records and of the jurisdiction of Jhalawar district, southeast region of Rajasthan and it's neighbourhood region, alleged to have sexually assaulted by any random person or relatives or known person during the period of January 2019 to December 2020, after taking approval of the Institutional Ethical Committee.

Inclusion criteria- All the cases of alleged history of sexual assault who have given consent for their medico legal examination during the mentioned study period.

Exclusion criteria : Cases who have refused or did not give valid consent for their medico legal examination.

Collection of Data : Each sexual assault case will be studied in detail using specific proforma. The primary data will be collected from sources such as hospital records about finding & examination of cases, police forwarding inquest reports, history statements revealed by victims & relatives, findings from physical examinations, indoor notes in case of hospitalized victims. Later each case will be analyzed and compared on various indices & parameters such as simple frequency distribution and cross tabulations will be carried out to draw conclusions and observations.

Aims and Objectives : 1. To study various aspect of sexual assault cases and incidence of number of sexual assault cases in Jhalawar and southeast region of Rajasthan and it's neighbourhood region, brought to S.R.G. Hospital, Jhalawar medical college, Jhalawar, Rajasthan.

2. To study various distribution of sexual assault cases in various population - a) Age & sex distribution b) Religion wise distribution Profile of victims c) Rural & urban distribution d) Socioeconomic distribution e) Occupational distribution f) Marital status among sexual assault cases g) Relationship of victim to the perpetrator. h) Time interval between incident & examination of victims. i) Distribution about Presence or absence of types of injuries on genitals and on other body parts.

Observation : The present study was conducted on the female and male survivors of alleged sexual offence who were brought to S.R.G. hospital, Jhalawar medical college, Jhalawar, for the examination during the period of 2 years from January 2019 to December 2020. The total number of cases reported were 382 to the hospital with alleged history of sexual assault, of which 287 gave inform consent for examination. The numbers of female victims were 285 and male victims were only 2. The findings of our study were compared with the findings of studies by other authors in the present study, out of the 287 victims, maximum 179 (62.36%) belong to the age group of 11-20 years followed by 65 (22.64%) cases in the age group of 21-30 years and 21 (7.31 %) cases in the age group of 31-40 years [Table 1].

2. Religion wise distribution of sexual assault cases. Most of the alleged sexual assault cases were reported from Hindu and Muslims community. Most of the female victims were Hindus 266 (92.68%) followed by Muslims 21 (7.32%) as the reason being Hindus are the most common population living in and around this region.

3. Area wise distribution of sexual assault cases. In this present study it was observed that sexual offence victims were more common from rural area population 209 (72.8 82%), and followed by urban area population 78 (27.18%) of total cases reported.

4. Socioeconomic status distribution of sexual assault cases. In this present study we observed that majority of the victims 135

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(47%) belong to lower class of socioeconomic status, closely followed by lower middle class

133 (46%) cases. The least number of victims 19 (7%) were from upper middle class .

5. Marital status distribution of sexual assault cases. The majority of victims of alleged sexual assault in our study were unmarried 190 (66.20%) compared to the married victims 97 (33.8%), in the ratio of 2 : 1.

6. Occupation wise distribution of sexual assault cases [Table 2].

In our present study we observed that the maximum number of survivors 121 (42. 16%) were students followed by 82 (28.57%) house wives & 54 (18.81%) laborers [Table 2].

7. Relationship of victim to the perpetrator [Table 3].

In our present study, similar to our social stigma, we observe that in majority of cases 212 (73.86%) the perpetrator was stranger to the victim, followed by victims male friend/boyfriend 32 (11.15%) and neighbours 22 (7.66%) cases [Table 3].

8. Time interval between incident and examination of victims [Table 4].

In our study we observed that majority (19.16%) of victims were examined in < 24 hours (out of which 7.66% were examined within 12 hours), followed by 18.46% victims examine between 4-7 days and 18.46% after 2 months [Table 4].

9. Presence or absence of types of injuries on genitals [Table 5].

Hymen tears were found in 275 (95.82%) victims, rest 12 (4.18%) have intact hymen. Recent or fresh torn hymen were seen in 9.06% cases only while old torn hymen were present in 86.75% victims [A].

In the present study, we came across 10 (3.48%) survivors sustained genital injuries in which bruises were most common (1.75%), abrasion 4 (1.40%) and laceration found in only 1 (0.35%) case. Most (3 cases) of bruises or redness were on external genitalia i.e. Labia majora, following by vaginal introitus (2 cases). The tear/laceration found in one particular case was on vaginal introitus. Abrasions were found at places including 2 abrasions on labia majora, one abrasion on labia minora right side to clitoris, and 1 liners abrasion at anal region [B]. Extra genital injuries were present in 11 (3.83%) cases only, of which most of the injuries were present in lower limb (45%) followed by upper limb (36%) and (9% each) on head and neck and breast and trunk region [Chart 1]. The most common extra genital injuries were abrasions 45.45%, followed by bruises 27.27% , few like swelling and fracture.

Table 1 : Age and sex wise distribution of sexual assault cases.

Age (Year)	Female	Male	Total (percent)
0-10	8	2	10 (3.4%)
11-20	179	0	179 (62.36%)
21-30	65	0	65 (22.64%)
31-40	21	0	21 (7.31%)
41-50	8	0	8 (2.78%)
51-60	3	0	3 (1.04%)
>60	1	0	1 (0.3%)
Total	285	2	287

T.2: Occupation	No. of cases (percentage)
Farmer/Agriculture work	22 (7.66%)
Laborer	54 (18.81%)
Student	121 (42.16%)
Housewife	82 (28.57%)
Govt./Pvt. Employed	1 (0.36%)
Others	7 (2.44%)
Total	287

T.3:Relation	No. of victims	Percentage
Father	3	1.04%
Husband	1	0.3%
Boy friend	32	11.15%
In laws	2	0.69%
Neighbour	22	7.66%
Stranger	212	73.86%
Colleague	2	0.69%
Others/Known Relatives	13	4.52%
Total	287	100%

Discussion:

The present study showed maximum 179 (62.36%) belong to the age group of 11-20 years and findings were consistent with most of other studies.[1,5,10,11,12] Despite similar observations, that the most vulnerable group was between 11-20 years, this shows that no age group is safe from being sexually assaulted. Male victims of sexual assault cases were only 2, both being less than 10 year of age. Both the alleged male victims' cases were reported with the history of being forcefully subjected to act as a passive agent of anal intercourse and were minors. Our this observation was consistent with the study done by Bhowmik k., et al.[11]

In this study, most of the female victims were Hindus 266 (92.68%) followed by Muslims 21 (7.32%). The observations were consistent with the studies done by other authors1,[11] as in Hindu dominant population it is quite obvious. On contrary, local living population in Manipur “Meiti" was most common community of sexual offence cases as observed by Soreingam Ragui et al in their study.[12]

In this study, it was observed that most common sexual offence victims were from rural area population 209 (72.8 82%). This is because jhalawar region is mostly having agriculture based rural areas. Similarly, Rahul Jain, PN Mathur et al also is stated that 75% of women were from rural background as majority of cases brought to the hospital were from surrounding villages.[5]

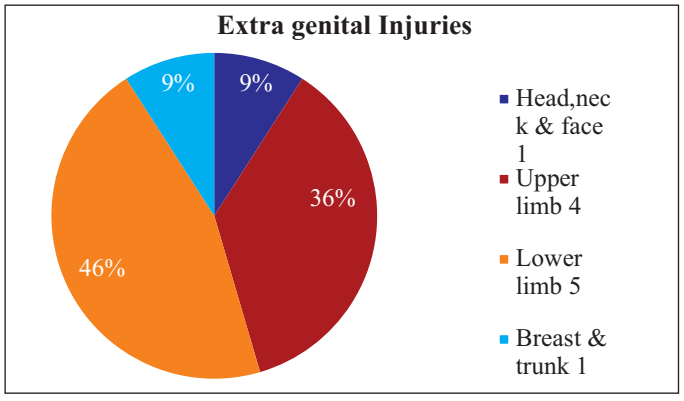
In this study we found that most of the victims 135 (47%) belongs to lower class of socioeconomic status. Our present finding were consistent with other authors stating in their observation the majority of victims 30% belong to lower class of social economic status,[10] while in other, 62.5% of victims were from lower socioeconomic group.[5] It's because most of population in this region have low income sources.

In our study we observed maximum number of survivors 121 (42. 16%) were students. This was consistent with studies done by other authors, stating the maximum number of survivors were students, accounting for [redacted]50% cases.[10,11,12] On contrary, our finding differ from the study done by Rahul Jain, PN Mathur et al, in which majority of survivors (43.5%) were housewives.[5]

In our study, most victims were unmarried 190 (66.20%) and this observation was consistent with most of other studies.[9,10,12] On the contrary observations done by Rahul Jain, PN Mathur et al were contradict, stating the majority (56.5%) of victims being married.[5]

In our study, in majority of cases 212 (73.86%) the perpetrator was stranger to the victim. Our findings were contradict to most of the studies done by other authors. Such as, perpetrators and victim being reside in the same residential area/neighbourhood (67.25%)[9] or boyfriends being perpetrator (58%)[1] or somehow survivors knew the alleged perpetrator (78.3%)[10,12] or perpetrators were victim's friend (39%)[6] or perpetrator being neighbours (46.75%)[5] or perpetrator was male friend of victim (55.4%).[11] Our study found as social stigma goes that strangers are more likely to be perpetrators but other studies suggest that contrary to our social stigma, a well known person can also be a perpetrator.

Anatomical part (A)	Fresh Torn	Old Torn	Intact	Total
Hymen	26 (9.06%)	249 (86.75%)	12 (4.18%)	287 (100%)
(B)	**abrasion**	**Bruise/ Redness**	**Laceration/Tear**	
Labia Majora	2	3	-	
Labia Minora	1	-	-	
Vaginal introitus	-	2	1	
Anal introitus	1	-	-	
Total Genital Injuries	4 (1.40%)	5 (1.75%)	1 (0.35%)	



Time Interval	No. of Victims (percentage)
< 12 hours	22 (7.66%)
12-24 hours	33 (11.50%)
24-48 hours	22 (7.66%)
48-72 hours	22 (7.66%)
4 - 7 days	53 (18.46%)
1 - 2 weeks	35 (12.20%)
2 weeks – 2 months	47 (16.37%)
>2 months	53 (18.46%)
Total	287

In our study we observed that majority (19.16%) of victims were examined in < 24 hours (out of which 7.66% were examined within 12 hours). The time interval between assault and examination of victim play a major role in knowing the nature and pattern of assault cases. The delay may be due to lack of gynecologist at primary level hospitals as 72.8% cases were reported from rural areas and referring patients to higher centers for medical examination.Our findings were similar to other studies done by some of authors.[1,5] On the contrary to our findings, Amandeep Singh et al stated that majority (26.6%) were examined between 24-48 hours.[10]

In freshly ruptured hymen, bleeding or blood clot is found to be attached at margins. It becomes inflamed and swollen till 4-6 days following trauma and generally heals by 7-10 days. In our study Hymen tears were found in 275 (95.82%) victims, with fresh torn hymen in 9.06% cases only and old torn hymen in 86.75% victims. It was consistent with most of other studies.[1,10,11,12] The fact that the most of victims had old healed hymen tear without any signs of violence suggesting previous consensual sexual activities and later either parents/relatives or husbands made allegations against the accused with a bad intention/motive or just to defame him or for monetary gain.

In this study, almost all injuries were presented with redness around genitalia and bleeding or blood mixed stains in 2 cases. Genital injuries were not commonly present in victims (only 3.48%) with bruises being most common (1.75%). Our observation was consistent with studies done by authors, such as genital injuries in 23.3% only and bruises as most common genital injury[10], genital injuries (33.3%),[12] genital injuries in 12.5% of cases with majority as contusion of genitals[5] and genital injuries in 5.6% cases only.[11] The Extra genital injuries were present in 11 (3.83%) cases only, most common site being on lower limb (45%) and type being abrasions (45.45%). On the contrary to our observation, Amandeep Singh et al stated most common injury as bruises and most commonly present on upper limb region.[10] Rahul Jain PN Mathur found that in 37.5% cases injuries and signs of struggle were present and most of them (55%) were seen on breast and trunk but similar to our study, they were abrasions mostly.[5] The reason for this finding could be either consensual intercourse earlier and later being accused or very less actual assault cases as in actual sexual assault, obviously victims would struggle and try to save herself or accused would try to harm bodily (both genital and extra-genital) due to rage or violent

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nature.

Conclusion :

We have come across that in 95 of 382 (25%) allegations, victims refused to give consent & subsequently avoided medico-legal examination, may be due to social stigma, having love affair or chances of marriage in future, being held responsible for incident, public embarrassment or losing social respect etc. Sometimes these false allegations were made with bad intentions/motive or just to defame the accused. These cases not only put an unnecessary burden to medical and legal departments but also causes mental harassment to innocent men. There should be some strict laws to punish such persons.

On other hand, true cases either are really under reported or being delayed for medical examination, results in the loss of vital medico legal evidences and typical injuries. Proper history, prompt physical examination with in a significant time, is the only way to accurately diagnosing true case of sexual assault.

Multidisciplinary approach, emotional, medical, psychological and social support with forensic care is required. All educational institutions and workplaces should conduct counselling programs and help corners in their premises. Necessitate sex education at school level with proper guidance & insight about the medical, social and legal implications in such incidents. Moreover, teaching various tactics to all girls and women for handling and preventing such incidents, raising awareness about sexual assault could be crucial in reducing risk.

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ORIGINAL ARTICLE

Stature Estimation from Hand Measurements in South Indian Population

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Abstract :

In many cases, only a part of the body may be found in the crime scene. In such cases, partial identification of the deceased is possible. Stature is one such criterion which helps in the partial identification of an unidentified body. Researchers have estimated the stature where only a fragment of a body part like a hand is available. But owing to the geographical diversity, the same formula may not be applicable to all. Hence this study was undertaken to see the relationship and estimate the stature from different hand measurements in a south Indian population. The overall maximum correlation was found in right palmar length among males (r=0.567) followed by left palmar length among females (r=0.559). The palm length showed a higher correlation with stature than the palm breadth in both sexes. In females, the least correlation with stature was found with the right middle finger length (r=0.186), followed by the left middle finger length (r=0.191). Among the digits, the right middle finger length of the males showed a higher correlation (r=0.372) followed by the left middle finger length of males (r=0.370).

Keywords : Stature estimation; Hand measurements; Palm length; Palm breadth; Finger length; South Indian population; Regression equation.

Introduction :

Establishing identity is necessary in living persons, decomposed bodies, mutilated remains, and persons who are found missing and dead in the recent past.[1] In natural or man-made mass casualties like earthquakes, tsunamis, cyclones, floods, aviation accidents, terrorist activities, fire accidents, homicide etc. most of the body parts may be partially lost or disfigured. Amongst the body fragments that are found at the disaster site, hands and feet are the most commonly recovered parts.[2,3] The forensic experts can help in the partial identification of the deceased by estimating the stature from these fragmentary remains. There are few studies, regarding stature and its relation to palm length, palm breadth and finger length in different regions of the world. India is a populous country with various ethnic groups and no single formula may be applicable for estimating the stature.[4] The objectives of the study were to assess the relationship of stature with palm length (PL), palm breadth (PB) and finger length (FL) in the South Indian population and to develop a predictive model for stature using different hand measurements in the said population.

Material and Methods :

Study participants

South Indian Population - The individuals for the study were born and brought up in south India and belonged to an area encompassing the South Indian States of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Telangana and the Union Territory of Puducherry. A total of 500 subjects were recruited for the study from the defined south Indian population. The sampling was convenient sampling and the subjects were mainly the attenders of the patients who had come to our hospital for treatment. All the subjects were recruited after thoroughly screening for the inclusion and exclusion criteria. Individuals in the age group of 21 to 60 years belonging to the above-defined population were included in the study. People with any congenital or acquired hand deformity, hand fracture and its complications, and visible defects of the skeletal system affecting the stature were excluded from the study.

Study procedure

The study was a descriptive cross-sectional study. After obtaining clearance from the institute ethics committee, the study was started. Participants were requested to assemble in the forensic laboratory present in the department of forensic medicine. As an alternative method, measurements were taken in the respective places of those participants who were not able to come to the forensic medicine laboratory. Informed written consent was taken from the participant after explaining the procedure in the language they understood. Each participant was assigned a serial number in order to maintain confidentiality. The following measurements were taken in the subjects from proper anatomical landmarks defined in various literature.

Stature - It is measured as the vertical distance from the vertex to the footrest of the stadiometer (IS Indo Surgicals private limited, New Delhi). Measurement was taken by making the participant to stand erect on a horizontal resting plane, barefooted with a shoulder band touching the stadiometer rod. Palms of the hand were turned inwards and fingers pointing downwards. The subject was made to stand over the footrest of the stadiometer with the head oriented in the eye-ear-eye plane (Frankfurt Plane). The movable rod of the stadiometer was brought in contact with the vertex in the mid-sagittal plane. Height was noted in the data

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collection proforma in centimetres.

For measuring the PL, PB and FL, the participant was asked to place his hand on a flat table with fingers adducted, except the thumb finger which was abducted. All the hand measurements were taken using a digital vernier calliper (Aerospace, New Delhi of length 300mm).

Palm length - PL was measured as the distance between the midpoint of the distal wrist crease and the tip of the middle finger using the digital slide calliper. PL of both hands were marked in their respective data collection proforma.

Palm breadth - PB was measured between the radial side of the second metacarpophalangeal joint and the ulnar side of the fifth metacarpophalangeal joint using the digital slide calliper. PB of both hands was marked in their respective data collection proforma.

Finger length - The distance between the midpoint of the proximal crease of the proximal phalanx and dactylions (tip of the finger) of the second to the fifth finger was taken using a digital slide calliper. Finger lengths of both hands were noted in their respective data collection proforma.

Statistical analysis

All these measurements were assessed twice by the investigator to ensure the intra-rater reliability of the measurement. Inter-rater reliability was assessed by measuring the parameter by an independent person. All lengths were measured in centimetres to the nearest 0.1mm. The obtained data were tabulated and analyzed using a relevant statistical test. The distribution of continuous variables such as age, PL, PB, FL and stature was expressed in terms of mean with standard deviation. The distribution of categorical variables like gender was expressed in terms of frequency and percentage. The relationship between the statures with different hand measurements was carried out by using correlation analysis. The predictive model for stature with different hand measurements was developed by using regression analysis. The intra-observer reliability (consistency) was assessed by using test – retest method by measuring the length 3 times by the observer and the inter-observer reliability was carried out by measuring the length by two independent observers. The inter-rater reliability was assessed by using the ICC (intra-class correlation coefficient). The intra-rater reliability was assessed by using the Cronbach alpha coefficient. All statistical analyses were carried out at a 5% level of significance with p value <0.05 considered as statistically significant. It was observed that both intra and inter-observer reliability on the measurements were found to be excellent (ICC=1.00).

Table 1. Distribution of study subjects in relation to different study variables. All variables are expressed in cm except for age which is expressed in years

	Males				Females			
	Min	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**
Age	22	59	40.15	10.88	22	59	41.72	10.78
Stature	153	190.1	168.35	6.46	136.8	179.5	162.14	7.42
RPL	14.67	21.47	17.53	1.14	13.87	19.52	16.20	0.92
RPB	5.05	9.09	7.28	0.74	4.83	8.22	6.34	0.64
RIFL	4.87	9.27	6.84	0.72	4.17	7.78	5.88	0.65
RMFL	5.6	9.64	7.45	0.78	5	9.01	6.43	0.68
RRFL	5.28	9.57	7.14	0.76	4.1	8.16	6.16	0.66
RLFL	3.26	8.57	6.30	0.72	3.9	7.44	5.53	0.63
LPL	14.63	21.25	17.54	1.14	13.84	19.47	16.20	0.91
LPB	5.05	9.09	7.28	0.74	4.84	8.19	6.34	0.64
LIFL	4.89	9.27	6.84	0.73	4.11	7.73	5.90	0.65
LMFL	5.21	9.77	7.48	0.81	4.99	9	6.43	0.68
LRFL	5.29	9.56	7.13	0.74	22	59	41.72	10.78
LLFL	4.57	8.57	6.33	0.68	136.8	179.5	162.14	7.42

Results :

500 subjects participated in this study, out of which 248 (49.6%) were males and 252 (50.4%) were females. The mean stature was significantly higher in males (168.35 + 6.46 cm) than in females (162.14 + 7.42 cm) (Table 1). The mean palm length (MPL) for males was 17.53 cm and 17.54 cm with a standard deviation of 1.14 cm for the right and left sides respectively where as for females it was 16.20 + 0.92 cm. The mean palm breadth (MPB) was 7.28 cm with a standard deviation of 0.74 cm for males and 6.34 + 0.64 cm for females (Table 1). The correlation coefficient determines the strength and the direction of a linear relation between two variables. Pearson correlation was used to determine the association between the different variables and stature. The correlation coefficient on the right side was higher than the left for both sexes for MPL and MPB. In the case of males, the left side fingers had a higher correlation coefficient except for the middle finger. All the hand measurements showed a statistically significant positive correlation with stature with a p-

Table 2 LRE from study variables in males.

Variables	LRE	SEE	R	R^2	p - value
RPL	S = 111.825 + 3.226 * (RPL)	5.334	0.567	0.322	< 0.001
RPB	S = 145.482 + 3.141* (RPB)	6.043	0.360	0.130	< 0.001
RIFL	S = 148.754 + 2.866* (RIFL)	6.137	0.320	0.102	< 0.001
RMFL	S = 145.439 + 3.078* (RMFL)	6.012	0.372	0.138	< 0.001
RRFL	S = 147.058 + 2.984* (RRFL)	6.067	0.350	0.123	< 0.001
RLFL	S = 152.309 + 2.546* (RLFL)	6.214	0.282	0.080	< 0.001
LPL	S = 112.793 + 3.168* (LPL)	5.372	0.559	0.312	< 0.001
LPB	S = 146.470 + 3.005* (LPB)	6.082	0.344	0.118	< 0.001
LIFL	S = 148.525 + 2.900* (LIFL)	6.117	0.329	0.108	< 0.001
LMFL	S = 146.319 + 2.948 * (LMFL)	6.017	0.370	0.137	< 0.001
LRFL	S = 147.224 + 3.106 * (LRFL)	6.048	0.358	0.128	< 0.001
LLFL	S = 148.304 + 3.170* (LLFL)	6.101	0.336	0.113	< 0.001

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Table 3 Table showing the LRE from study variables in females

Measurements	LRE	SEE	R	R^2	p - value
RPL	S = 104.860 + 3.536 * (RPL)	6.690	0.437	0.191	< 0.001
RPB	S = 141.347 + 3.278 * (RPB)	7.135	0.283	0.080	< 0.001
RIFL	S = 145.954 + 2.751* (RIFL)	7.223	0.239	0.057	< 0.001
RMFL	S = 149.107 + 2.029* (RMFL)	7.310	0.186	0.035	< 0.001
RRFL	S = 147.275 + 2.413* (RRFL)	7.265	0.215	0.046	< 0.001
RLFL	S = 144.448 + 3.200* (RLFL)	7.161	0.271	0.073	< 0.001
LPL	S = 104.343 + 3.569 * (LPL)	6.687	0.438	0.192	< 0.001
LPB	S = 141.847 + 3.199* (LPB)	7.147	0.277	0.077	< 0.001
LIFL	S = 146.222 + 2.700* (LIFL)	7.226	0.238	0.057	< 0.001
LMFL	S = 148.658 + 2.096 * (LMFL)	7.302	0.191	0.037	< 0.001
LRFL	S = 146.531 + 2.527* (LRFL)	7.250	0.244	0.050	< 0.001
LLFL	S = 144.561 + 3.177* (LLFL)	7.167	0.268	0.072	< 0.001

value of < 0.01.

Linear regression equation (LRE) was found out individually for all the variables for the right and left sides of both sexes (Table 2, 3). R^2 value was highest for RPL in males with a value of 0.322 and lowest was 0.035 for RMFL in females. Among the fingers, the highest value was observed for RMFL in males. A multiple regression equation was used for all the variables taken together (Table 4). LRE given by the formula (y=a+bx) "y" is Stature, "a" is the intercept, "b" is the regression coefficient, "x" is Predictor variable e.g., Palm length, SEE - Standard error of estimate, R^2 – coefficient of determination. All linear regression equations were measured in centimeters.

Discussion :

The MPL and MPB of different studies were compared with our study (Table 5). There was not much difference between right MPL and left MPL in males and females individually in the current study. These findings were some what closer to many other studies.[5-11] The comparison of the different PL based on various region, suggest that the PL varied according to a different population. The MPL of the present study was less when compared to studies from other parts of India and the world.[4-10,12-17] Our study used the midpoint of the distal palmar crease to measure the PL which was also done in most of the other studies.[6,11,12,15-17] One study used proximal palmar crease and few other studies used the midpoint of the interstyloid process.[5,7,10,13,14,18] Rastogi et al performed measurements from the mid-point of interstyloid line and distal crease and studied the MPL. They observed a significant difference of 1cm in between the two lengths with the distal crease showing the lower value. So factors like methodology influenced the values obtained for MPL in different studies. The value was comparatively lower in our population, may be because the study population mainly belonged to the lower socio-economic status.

In this study, the MPB were similar to the study done in Maharashtra.[8] On the whole, the MPB of this study was less than

Table 4 Multiple regression equation (MRE) from all variables in this study.

	Side	Equation	R^2	SEE
Males	Right	S = 106.42 + 3.99 (PL) - 1.29 (PB) - 2.26 (IFL)- 0.264 (MFL) +1.05 (RFL) +1.79 (LFL)	0.351	5.270
	Left	S = 102.58 + 5.23 (PL) - 1.62 (PB) – 3.84 (IFL)- 0.38 (MFL) +1.36 (RFL) +4.01 (LFL)	0.374	5.176
Females	Right	S = 101.18 + 4.09 (PL) + 0.724 (PB) + 2.01 (IFL) – 5.75 (MFL) +0.89 (RFL)+ 6.05 (LFL)	0.255	6.488
	Left	S = 99.61 + 4.20 (PL) + 1.01 (PB) – 2.18 (IFL)- 7.69 (MFL) +3.26 (RFL) + 5.45 (LFL)	0.259	6.469

the other parts of India, Iranian, Slovakia, South Korea, Egyptian, Sudan Arab and the Chinese study.[4,5,7,9-12,14,16-18] The crucial role of genetics, nutrition, and environmental conditions in the growth of the bones could be the reason for the difference observed in PL and PB among various populations.[13] One study stated that PL and PB were influenced by the muscle contractions acting on the bone.[19] These factors influence the difference in the growth of PL and PB between the genders because of the difference in works done by them. Our study showed that there was a statistically significant difference in PL and PB between the males and females. Our study when compared with Rastogi et al. showed south Indians had smaller PL and shorter PB than north Indians with a significant difference between the LPL and RPL ($p<0.001$). A reason to substantiate the finding was the difference in the age group of participants studied in both studies. Our study was conducted in subjects above 21 years and below 60 years, while the other study included participants in the age group 20-30 years. This difference in the age group could be a reason because our study involved persons with cartilage and bones in various stages of wear and tear while the other study involved the age group in the initial stages of wear and tear.[20,21]

The mean index finger length (IFL) and mean ring finger length (RFL) measurements were higher in males than the females in the other studies (Table 6).[16,22-25] The scientific reason suggested behind these disproportions could be due to the hormonal influence on bone growth and development which ultimately leads to increased bone length in males than females. The estrogen hormone in females is a biphasic hormone which at low levels stimulates the growth of bones in males. Hence the lengths of bones are higher in males than in females.[26-29] In our study, the IFL in males were almost equal to the IFL of the Assam and North Bengal population studied by Sen et al but in the females, it was less when compared to them.[24] The difference between the mean IFL of the males and the females in our study was 0.95 cm and 0.94 cm in the right and left sides respectively and similarly the difference between the mean RFL of the males and the females in our study was 0.97 cm and 0.95 cm in the right and left side respectively. This was due to the influence of prenatal testosterone and estrogen on the relative growth rate of the index and middle fingers of the palm.[22,30,31] The RFL in our study was more than the IFL which was similar to three other Indian

Table 5 Comparison of the MPL and MPB with other similar studies. Figure mentioned inside brackets are the correlation coefficient values

Author	Place and Year of Study	MPL (cm)				MPB (cm)			
		Males		Females		Males		Females	
		Right	Left	Right	Left	Right	Left	Right	Left
Bhatnagar[4]	Punjab, 1984	19.42	19.30	-	-	8.38	8.32	-	-
Malek[14]	Egypt, 1990	19.88 (0.64)	19.98 (0.62)	18.28 (0.66)	18.25 (0.69)	8.3 (0.42)	8.15 (0.39)	7.48 (0.43)	7.39 (0.40)
Krishan[5]	Rajput, 2007	18.24 (0.59)	18.21 (0.60)	16.83 (0.68)	16.80 (0.67)	8.23 (0.51)	8.09 (0.53)	7.40 (0.50)	7.29 (0.40)
Laila[6]	Bengal, 2009	-	-	16.39 (0.68)	16.34 (0.68)	-	-	-	-
Kanchan[7]	Himachal Pradesh, 2010	18.3 (1.00)	18.2 (1.00)	16.8 (1.00)	16.8 (1.00)	8.2 (0.56)	8.1 (0.49)	7.4 (0.59)	7.3 (0.47)
Habib[15]	Egypt, 2010	19.29 (0.69)	19.29 (0.67)	17.60 (0.49)	17.60 (0.56)	-	-	-	-
Akhlaghi[16]	Iran, 2012	-	18.9	-	17.1	-	8.5	-	7.6
Tang[10]	Southern China, 2012	18.37 (0.65)	18.36 (0.66)	16.99 (0.65)	16.34 (0.63)	8.34 (0.37)	8.33 (0.36)	7.21 (0.34)	7.12 (0.35)
Ahmed[17]	Sudan Arab, 2013	19.16 (0.60)	-	17.25 (0.61)	-	7.91 (0.35)	-	7.03 (0.43)	-
Pal[13]	Odisha and West Bengal, 2014	18.79	18.83	17.11	17.14	-	-	-	-
Supare[8]	Maharashtra, 2015	18.46 (0.74)	18.42 (0.75)	17.25 (0.75)	17.22 (0.74)	7.53 (0.45)	7.51 (0.46)	6.34 (0.56)	6.43 (0.55)
Pal[9]	West Bengal, 2015	-	-	16.30 (0.68)	16.31 (0.68)	-	-	7.05 (0.53)	7.03 (0.52)
Uhrová[18]	Slovakia, 2015	18.70 (0.63)	18.73 (0.63)	17.21 (0.58)	17.21 (0.58)	8.48 (0.40)	8.51 (0.34)	7.58 (0.28)	7.59 (0.27)
Kim[11]	South Korea, 2016	18.42 (0.62)	-	17.05 (0.50)	-	8.37 (0.22)	-	7.50 (0.05)	-
Current study	Puducherry, 2019	17.52 (0.57)	17.54 (0.44)	16.19 (0.55)	16.19 (0.44)	7.28 (0.36)	7.28 (0.28)	6.34 (0.34)	6.34 (0.28)

studies.[22,23,30] The statistical tests between IFL and RFL showed significant sexual differences (P<0.001). The differences between RFL and IFL in both sexes were found to be more than the study done by other researchers.[22,30-33] The available literature show sthat only a few researchers had worked with the LFL, of which this study was a new one to the list. The length of the little finger was more than a three fourth of the length of the middle finger.[34-36] The reason for this variation needs further evaluation.

In our study, the PL showed a statistically significant correlation with stature and it was more on the right side in both sexes. Two Egyptian studies noted a higher correlation coefficient on the right side for males and the left side for females (Table 5).[14,15] One study on the Rajputs and another on the Chinese found the value to be higher on the right side in females.[5,10] No difference between the two sides was observed by Kanchan et al and Uhrova et al.[7,23] When the entire upper limb is not obtained and only the hand is obtained, the PL was considered as a good tool to estimate stature compared to other body parts.[18,19,37,38] The correlation coefficient of PB in our study on the right side of both genders was more when compared to the female population of some studies (Table 5).[11,20,39] On comparing with a study done in north India, the correlation values were found to be less in our study.[34] Similarly it was less than the females of studies done by Supare et al and Pal et al.[8,9] The correlation coefficients of PB among the Indian studies are higher than that done in Iran, Slovakia and Nigeria (Table 5).[16,18,39] Even though the MPB of our study was less than the international studies, the correlation coefficient was high. This indicated that PB is also a good predictor of stature in our study. When compared to PL, PB showed a lesser correlation with the stature like two other Indian studies.[7,8] In our study PL was a better predictor of stature than PB.

In general, it was observed that the correlation values were higher in studies where the study population was young.[9,16,22] Our study

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Table 6 Comparison of the mean IFL and RFL with other similar studies. Correlation coefficient values are given in the bracket.

Author	Place and Year of Study	IFL (cm)				RFL (cm)			
		Males		Females		Males		Females	
		Right	Left	Right	Left	Right	Left	Right	Left
Akhlaghi[16]	Iran, 2012	-	7.44 (0.66)	-	6.93 (0.43)	-	7.33 (0.48)	-	6.7 (0.57)
Krishan[22]	Himachal Pradesh, 2012	6.95 (0.71)	6.97 (0.74)	6.53 (0.53)	6.55 (0.48)	7.23 (0.67)	7.26 (0.45)	6.73 (0.67)	6.73 (0.36)
Bardale[23]	Maharashtra, 2013	7.35 (0.51)	7.34 (0.55)	6.80 (0.61)	7.53 (0.61)	7.66 (0.54)	7.67 (0.57)	6.93 (0.59)	6.92 (0.59)
Sen[24]	Assam and North Bengal, 2014	6.84 (0.57)	6.86 (0.56)	6.39 (0.64)	6.37 (0.65)	7.05 (0.56)	7.14 (0.54)	6.58 (0.63)	6.61 (0.65)
Ahuj[25]	Gujarat, 2014	7.3 (0.55)	7.3 (0.37)	6.6 (0.57)	6.6 (0.66)	7.4 (0.57)	7.4 (0.56)	6.6 (0.56)	6.6 (0.58)
Pal[9]	Odisha & West Bengal, 2014	-	-	6.51 (0.50)	6.52 (0.50)	-	-	6.65 (0.47)	6.64 (0.48)
Acharya[41]	Nepal, 2016	-	7.28 (0.33)	-	6.66 (0.50)	-	7.46 (0.23)	-	6.97 (0.48)
Current study	Puducherry, 2019	6.83 (0.32)	6.83 (0.33)	5.88 (0.24)	5.89 (0.24)	7.13 (0.35)	7.12 (0.36)	6.16 (0.21)	6.17 (0.22)

Table 7 Comparison of the mean MFL and LFL values with other similar studies. Correlation coefficient values are given in brackets.

Author	Place and Year of Study	MFL (cm)				LFL (cm)			
		Males		Females		Males		Females	
		Right	Left	Right	Left	Right	Left	Right	Left
Akhlaghi[16]	Iran, 2012	-	7.44 (0.674)	-	6.93 (0.644)	-	7.33 (0.483)	-	6.70 (0.317)
Ahuja[25]	Gujarat, 2014	8.0 (0.66)	8.0 (0.52)	7.2 (0.69)	7.2 (0.66)	6.0 (0.57)	6.1 (0.56)	5.4 (0.56)	5.4 (0.58)
Pal[9]	Odisha & West Bengal, 2014	-	-	7.16 (0.52)	7.18 (0.51)	-	-	5.32 (0.45)	5.32 (0.44)
Acharya[41]	Nepal, 2016	-	7.93 (0.23)	-	7.43 (0.48)	-	6.22 (0.14)	-	5.65 (0.23)
Current study	Puducherry, 2019	7.45 (0.372)	7.48 (0.370)	6..42 (0.186)	6.43 (0.191)	6.3 (0.282)	6.32 (0.336)	5.53 (0.271)	5.53 (0.268)

covered the age range of 21-60 years, who were in various stages of intervertebral disc degeneration which cannot be measured. The inference from a comparison of the Pearson correlation of various studies suggested that as the age increases, there is a fall in correlation values of the digit length due to degeneration changes.[21] In another study done on the same age group as ours, their correlation result were better than ours. This could be because they did their study in a tribal population of Assam and North Bengal. The genetic marker study among the population revealed that they belong to the clusters of mongoloids and caucasoids who get married among their own population and hence maintained their gene pool.[24] However, our south Indian population consisted of four different sub populations and there was no strict compliance about marrying within the same gene pool.

The correlation of middle finger length (MFL) to stature in the males of this study was found to be high when compared to Kumar et al (Table 7).[40] Even though the mean MFL of our study had the highest value amongst the studied variables, it showed a moderate correlation with stature. Compared to other fingers the mean MFL in females was found to be the least which suggested that MFL is a poor predictor of stature in females of our study. This finding is in contradiction to a few other studies.[9,16,39] Table 4 showed the MRE of all variables. The results of the MRE for the study were quite encouraging. The predictability of the regression models for estimating stature increased when multiple regression analysis was performed. The correlation values were found to be

increased when the variables were put together.

Conclusion :

This study revealed that estimation of stature was possible from different hand measurements from the defined south Indian population with the help of the predictive model developed. Hence, if the peripheral parts of the upper limbs namely the hands are found, the stature of the unknown individual can be approximately estimated. Maximum correlation with stature was found in RPL among males followed by LPL among females. The PL showed a higher correlation with stature than the PB among both pooled data and gender-wise analysis. Among the digits, the right MFL and left RFL showed a moderate correlation with stature among the males and females respectively. Stature can be estimated with greater precision among males than females when LRE is applied. Stature can be estimated with greater precision among females than males when multiple regression equations are applied.

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Conflict of interest :

The authors declare that there is no conflict of interest.

Ethical approval :

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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ORIGINAL ARTICLE

Significance of Spheno-Occipital Synchondrosis in Age Estimation - A Retrospective CBCT Study

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Abstract :

Spheno-occipital synchondrosis has a relatively late ossification which makes it utile for age estimation of the unidentified individuals. The present study aimed to assess the significance of spheno-occipital synchondrosis in age estimation and to evaluate the reproducibility and reliability of cone beam computed tomography (CBCT) for the same. CBCT mid-sagittal images of 50 patients between the age range of 10 and 25 years were used to assess the extent of fusion of the spheno-occipital synchondrosis, using a three-stage scoring. Complete fusion of the synchondrosis was evident in most of the females below 20 years of age while in males the complete fusion was depicted mostly above 20 years of age. CBCT with its cost-effectiveness and lower radiation exposure serves as a better source for spheno-occipital synchondrosis assessment with an appropriate resolution and multiplanar orientation.

Keywords : Skull base; Cranio-facial development; Cone beam computed tomography.

Introduction :

The centers of ossification appear early in embryonic life in the chondrocranium, and as the ossification proceeds, the cartilage band, called the synchondrosis, persists between the centers of ossification and will eventually be replaced by bone.[1] Synchondrosis in the cranial base is an important growth center of the craniofacial skeleton. Spheno-ethmoidal synchondrosis, inter-sphenoid synchondrosis, and spheno-occipital synchondrosis are the three synchondroses present along the midline in the cranial base.[2,3] The spheno-occipital synchondrosis (SOS) is a cartilaginous growth center between the occipital and sphenoid bones. It is composed of hyaline cartilage, which is abundant during the growth phase of the cranial base and then ossifies during skeletal maturation.[4] Growth at the spheno-occipital synchondrosis carries the maxilla upward and forward relative to the mandible resulting in an increased facial height and depth. Skeletal ossification points are the most important indicators for the estimation of age.[5] Besides, age estimation with skeletal evaluations is an important part of postmortem identification. On the other hand, the age estimation of the living individuals has an important role in guiding decisions for criminal and civil law. Age estimations between 15 and 18 years will fundamentally affect the legal decisions. The age for spheno-occipital synchondrosis ossification is relatively late, compared with other cranial base synchondroses that fuse prenatally (inter-sphenoid) or during early childhood (spheno-ethmoidal).[6] Although, Forensic experts employ the conventional methods for age estimation including but not limited to the hand-wrist and dental radiographs, the developmental differences among different populations have not been standardized for each population.[7] In addition to macroscopic and conventional radiographic examinations, additional methods, as well as computed tomography (CT) and magnetic resonance imaging, are recently investigated for guiding age estimation. The advantage of CBCT over medical CT has been investigated by various studies in recent years. Therefore, the present study aimed to assess the spheno-occipital synchondrosis for age estimation in the Chennai population and to investigate the reproducibility and reliability of CBCT evaluations for this purpose.

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Materials and Methods :

A retrospective study was conducted to evaluate the degree of fusion of spheno-occipital synchondrosis relative to the age of the individuals using CBCT. The study was approved by the institutional review board. The study population consisted of 45 CBCT full skull images of individuals between the age group of 10 to 25 years which were obtained for various dento-facial applications and were collected from the archives. A Planmeca CBCT machine was used to acquire CBCT images (Planmeca, Promax 3D max, Helsinki, Finland). Planmeca's proprietary software, Romexis, was used to reconstruct the images. Submillimeter slice thicknesses (0.2-0.4 mm) were preferred for the investigation of each plane, depending on the voxel size of the volumetric data. For the purpose of evaluating the fusion status in the mid-sagittal plane, the cranium is placed in a standard position using axial and coronal views. Each sphenooccipital synchondrosis' mid-sagittal images were exported and saved in JPEG format as the preferred view. The sample was divided into three groups i.e., group I (10-15 years), group II (16-20 years), and group III (21-25 years) to evaluate and assess the extent of fusion among the individuals under each category based on the age group. All the images of the individuals, which were of least diagnostic significance, individuals with a history of trauma,

surgical treatment in the region of interest, pathologies, and other craniofacial deformities were excluded. The selected CBCT full skull images were evaluated for the degree of fusion of spheno-occipital synchondrosis and were attributed a fusion score of 0, 1, and 2 accordingly for unfused, partially fused, and completely fused patterns seen on CBCT images (fig 1, 2, 3, 4). The scoring system was based on the previously affirmed studies using CT and CBCT for the assessment of spheno-occipital synchondrosis.[1,3,8]

Results :

The data were analyzed with Statistical Package for Social Sciences (SPSS) for Windows 20.0 (SPSS, Inc. Chicago, Illinois). Confidence intervals were set at 95% and values of $p < 0.05$ were interpreted as statistically significant. Chi-square analysis was done to know the association between different age groups and the stages of fusion. Chi-square tests were done to analyze the association of age group and degree of fusion within the age groups and among the genders and a p-value < 0.05 was considered significant (table 1). Spearman correlation value of 0.791 shows a good positive correlation between age and stages of fusion.

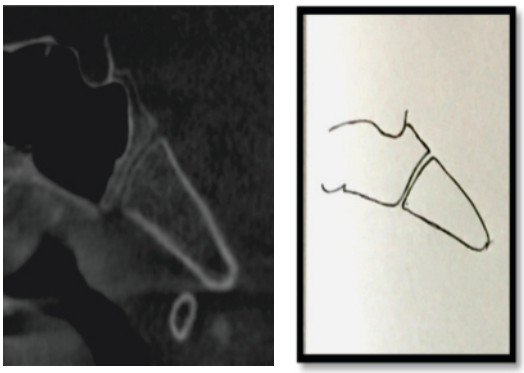

Figure 1: Unfused synchondrosis scored as "0"

Figure 2: Partially fused with the level of fusion evident Intra cranially scored as "1"

Figure 3: Line of fusion evident with progress extracranially and scored as "1"

Discussion:

The current study aimed to assess the degree of synchondrosis of sphenoid and occipital bones at the cranial base using CBCT images concerning different age groups of the sub-adult population in Chennai. The forensic, anthropological significance of the study of spheno-occipital synchondrosis is well affirmed. The proficiency of cranial base synchondroses and craniofacial development is of pronounced importance. The observations of Sahni et al in a study using radiographic and CT

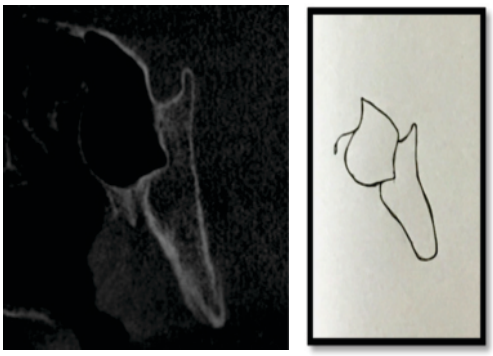

Figure 4 : Completely fused synchondrosis scored as "2"

Table 1 : Distribution of various Scorings among the Genders and different Age Groups.

Degree of fusion in comparison with Age group and Gender						
Gender			Age group			Total
			10 - 15 years	16 - 20 years	21 - 25 years	
Male	Degree of fusion	Unfused	7	0	0	7
		Partially fused	2	7	1	8
		Completely fused	0	5	13	17
	Total		9	12	14	32
Female	Degree of fusion	Partially fused	2	3	0	4
		Completely fused	0	5	5	9
	Total		2	8	5	13
Total	Degree of fusion	Unfused	7	0	0	7
		Partially fused	4	7	1	12
		Completely fused	0	8	18	26
		Total	11	20	19	45

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evaluation of autopsied skull bases show that in a male if a complete fusion has occurred, the age of the boy should be 15 years or above. In the case where there is no fusion or partial fusion, he should be below 19 years. In the case of females, fusion occurs between the ages of 13 and 17 years.[8] In the present study, the scoring of fusion was asserted among the age groups. Group I constituting the individuals of age group 10-15 years depicted a scoring value of 0 and has not presented with synchondrosis. In group II constituting individuals of 16-20 years, CBCT images with partial and complete fusion were elicited. Bassed and colleagues, in a CT-based analysis, showed that the fusion begins superiorly and progresses inferiorly, as shown by Irwin in conventional radiography–based study.[9,10] The fusion of the spheno-occipital synchondrosis begins at the endocranial surface and progresses to the ectocranial surface, which was observed by Okamoto et al using a high-resolution CT.[11] In the current study, all the individuals below 20 years of age were probably in the different phases of growth which were demonstrated as a partially fused state of synchondrosis. In a study by Sinanoglu A et al, the spheno-occipital synchondrosis was found to be an important marker of age estimation in a Turkish subpopulation with the use of CBCT, where a 4-staged scoring system was used in a population aged between 7–25 years. In the present study, an age range between 10 and 25 years was chosen and a combined three staged system, where the stages depicting endocranial and ectocranial fusion were included or scored together as "1" i.e., partially fused. In a meta-analysis by Okamoto et al, the studies that used CT were evaluated, and the observed age of synchondrosis is reported to be 8 to 13 years.[11] Mann et al and El-Sheikh et al both suggest that the complete fusion synchondrosis age is 16 years in women and 18 years in men, whereas Bassed et al reported this at age of 17 years for both sexes, and Franklin and Flavel reported this at age of 18.62 years in women and 19.83 years in men.[9,12,13,14] Although this is in complete agreement with the present study where the females presented with an early fusion of the joint compared to the males, an unequal sample distribution among males and females in the current study is a potential limitation.

Since the studies conducted earlier were within the populations of specific ethnic groups, a clear emphasis on the reliability of age estimation using synchondrosis as a parameter in CBCT evaluation is restricted to the legal guidelines within those races and ethnic groups. In Indian case scenarios, with the introduction of the Juvenile Justice Act in 2015 and sub-section 13 of section 2, a "child" means a person who has not completed 18 years of age.[15] Hence, with consideration of these tenuous aspects of Indian law, age estimation using advances in Medicine, Dentistry, and allied sciences for evaluation of skeletal and dental maturity indicators serves as a key tool in legal proceedings of juvenile and adult heinous crimes.

CBCT with its pertinence of cost-effectiveness, lower radiation exposure, and comparable diagnostic value of images serves as a better source of evaluation of synchondrosis of sphenoid and occipital bones with an appropriate resolution, slice thickness, and multiplanar orientation. However, owing to the fact that the sample size of the current study is small, further research with an extensive sample size involving diverse populations is warranted.

Conclusion :

Age estimation has profound importance in forensic and other medical sciences which would further pave a path for legal proceedings. Besides, it has a significant role in the planning and evaluation of treatment outcomes associated with craniofacial growth and development. Skeletal ossification points are the most important indicators for the estimation of age. CBCT with its added advantages of being cost-effective, of lesser radiation dose, and in conformity with well-maintained dental or medical archives serve as a great source of assessment of synchondrosis of sphenoid and occiput for age estimation. However, the ethnic group considerations, racial discrimination remained an area to be consolidated in population-based studies eminently, in the field of Forensics, where it serves as a parameter that cannot be disdained. Hence, further research using medical and radiological advances with a correlated dental and skeletal developmental index delivers a better and more reliable method of analysis of the age of the individuals of the unknown age.

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ORIGINAL ARTICLE

Presence of Diatoms in Kidney from Non-Drowning Cases: An Autopsy-Based Study

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Abstract :

On various occasions, diatoms have come to the rescue of Forensic pathologists who were at a loss for clues about the cause of death in corpses recovered from the water. Studies have shown the presence of diatoms in organs of non-drowning deaths as well. The study was to identify the presence of diatoms in kidney tissues of persons who died due to causes other than drowning. Autopsy of 75 non-drowning cases were performed, and tissue from one of the kidneys were collected. The sample comprised 62 males (82.7%) and 13 females (17.3%). Variables such as age, sex, diet preference, and source of drinking water were collected. The kidney was subjected to acid digestion, and the presence and the type of diatoms in it was recorded. Diatoms were found in the kidney in 42 cases (56%); among this, there were 39 cases (92.8%) containing pennates and three cases (7.2%) containing centrales. There was no statistically significant relationship between the presence and absence of diatoms and the sex, age, dietary habits, or drinking water source. One significant observation was that the pennates were significantly larger than the centrales (p 0.023). The mere presence of diatoms in the kidney cannot be taken as evidence of drowning.

Keywords : Diatoms; Kidney; Acid digestion technique; Drowning deaths; Non-drowning deaths.

Introduction :

Worldwide, drowning is considered as the second most common cause of death.[1] In the state of Kerala, with a six hundred kilometers long coastline, forty-four rivers, dozens of backwaters, innumerable wells, and ponds, drowning is one of the leading causes of death.[2] As the majority of the drowned dead bodies are recovered in a highly putrefied state, it will be very difficult to observe the morbid anatomical findings which are pathognomonic of drowning. Such situations are very common, where there is a delay in recovering the dead bodies from the water and subjecting them for autopsy. All these bodies may not have died of drowning. Causes of death in bodies retrieved from water are natural diseases before submersion, injuries before and during submersion, effects of immersion other than drowning. Yet another situation could occur where a body was drowned at a place and was later moved from the site of drowning to another location.[3] It is very important to differentiate the above situations. Thus, the diagnosis of drowning cannot be based solely on circumstantial evidence or non-specific autopsy findings and is often a diagnosis of exclusion.

When all the classical clinical signs of drowning are blurred, especially in putrefied corpses, ancillary investigations, like histology, biochemical analyses, and microscopic observations are resorted to for making the diagnosis.[4] Various tests like toxicological screening to rule out poisoning, histology of various tissues to rule out other causes like myocardial infarction, head injury etc. may be conducted before confirming the cause of death as drowning.[5] Histological findings, especially of the lung tissue, are an important investigative tool. Biological tests are also used in the diagnosis of death in corpses recovered from the water. Electrolyte shifts like differences in the blood sodium, chloride, and potassium ion concentrations between the right and left chambers of the heart and blood strontium levels have been used as corroborative evidence in such cases.[6]

Of the histological tests, diatom analysis in the body of body tissue is one of the most important tests used by Forensic experts worldwide. Diatoms are microscopic unicellular algae present in water bodies, soil, damp places, etc, and are the most common types of phytoplanktons. Their size ranges from 2 to 200 microns. They are encased within a tough silica coating called the frustules. Demonstration of the presence of diatom frustules in the internal organs of drowned victims, using the "diatom test," is considered as supportive evidence in deaths due to drowning. The silica-based extracellular coat of diatoms is resistant to putrefactive changes. So, even in decomposed bodies, where the typical features of drowning are absent, diatoms may be easily demonstrated.[6] When a person drowns, inhalation of diatoms from the downing water medium occurs. These diatoms enter the systemic circulation and embolises into the internal organs of the drowning person.[7]

This study has been undertaken to identify the presence of diatoms in dead bodies of victims who died of causes other than drowning. Also, an effort has been made to find out the possible sources of diatoms in those cases. Bits of tissues from kidneys

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were collected from the dead bodies of non-drowning cases and subjected to diatom tests. Detailed information about the dietary habits, source of drinking water, and occupation of the deceased is collected from the next of kin and police to identify the possible portal of entry of diatoms in the subjects included in the study

Methodology :

The study was aimed at the detection of Bacillariophyceae (diatoms) class of Phytoplankton inhuman organs. The study material consisted of tissue samples from the organs of cadavers brought for autopsy in Amrita Institute of Medical Sciences, Kochi, and Ernakulam General Hospital. A total of 64 renal capsules from the kidney was stripped off, and 50 grams of tissue from one of the kidneys is cut using a sterile blade. A total of 75 non-drowning cases with known causes of death were included in the study. No preservatives were used owing to the chances of contamination from the preservatives. The tissues were stored in a deep freezer to prevent decomposition of the tissues if immediate digestion was not possible.

The details for the proforma were collected simultaneously from the relatives accompanying the deceased and the police. The proforma included the serial number or the case number, the crime number of the case registered, autopsy number, name, age, sex and occupation, dietary habits, the primary source of drinking water, type of purification methods used.

The collected tissues were digested by using the digestion technique followed by Timper man in1962.[8] 10ml of concentrated nitric acid was added to the conical flasks containing the minced tissues and mixed well, and covered with a glass funnel. The conical flasks containing the mixture were then placed in a water bath set to a temperature of 650 C till the solution became clear. Following this, the solution was cooled to room temperature. Five milliliters of double distilled water were added to this to dilute the solution and to prevent further damage to the diatom frustules by the strong acid. The solution was transferred to a centrifuge tube. Separate centrifuge tubes were used for each specimen. The samples were then centrifuged for 20 minutes at 3000 rpm.[9] The supernatant fluid was discarded. The residue was washed twice with doubled stilled water, the resultant pellet along with one milliliter of the solution was mixed well so that the pellet breaks off and the resultant one milliliter solution has a uniform distribution of these diments. A drop of this mixture was then taken using a glass pipette and transferred to a glass slide. It was then air-dried, and the slide is covered with a coverslip and preserved by adding DPX mountant along the sides of the coverslip.[10] The slides were labeled. Specimen number was marked on one edge of the slide, and the tissue name was marked on the other edge for easy identification.

The diatoms found in the slides were counted, and pictures of each were taken using Nikon DS Qi1Mc camera. Each sample was screened for diatoms using 1000x magnification using the oil immersion objective of the microscope. The strip technique of counting the slides was used, starting from the top left end of the area occupied by the cover slip and ending at the bottom right end.[10] Diatoms were identified based on their morphological features, which included the bilateral or radial symmetry of the frustules and or the serrations. The number of centrales and pennates observed was counted and recorded from all the slides. The lengths of the diatoms were measured using the Image J software 1.47 version. Statistical analysis was done using the software IBM SPSS version 20.

Results :

Out of 75 cases studied, 62 were males (82.7%), and 13 were females (17.3%). Among this, 24 cases consumed corporation/municipality water as their only drinking water source. Five cases used well water as their only drinking water source and 45 cases used corporation/municipality water and well water both as their drinking water sources. There was only one case in which corporation/municipality water and purified water (the purification method adopted was mechanical and ultraviolet filtration methods) were used for drinking. In this case, the corporation's water was purified before consumption. Diatoms were seen in the kidney in 42 cases (56%); among this, there were 39 cases (92.8%) containing pennants and three cases (7.2%) containing centrales (Table 1). Of the 42 cases in which kidneys had diatoms, 34 were males, and 8 were females. There were 10 cases belonging to the age group above 60 years; 14 cases belonging to age groups between 46 and 60 years, 10 cases belonging to the age group 31 to 45 years, and 8 cases belonging to less than 30 years. There were two vegetarians and 40 non-

Table 1 : Pattern of Distribution of diatoms in Kidney tissues.

Specimen	Pennate	Centrale	Both centrale and pennate	No diatoms
Kidney	39(92.8%)	3(7.2%)	0	42(56%)

Table 2 : Pattern of distribution of diatoms in kidney.

KIDNEY		Diatoms absent		Diatoms absent		P value
		Number	Percentage	Number	Percentage	
Sex	Male	28	45.2%	34	54.8%	**0.66**
	Female	53	8.5%	86	1.5%	
Age	<30 years	64	2.9%	85	7.1%	
	31-45 years	63	7.5%	10	62.5%	
	46-60 years	11	44%	14	56%	
	>60 years	10	50%	10	50%	
Dietary habits	Vegetarian	3	60%	2	40%	**0.648**
	nonvegetarian	30	42.9%	40	57.1%	
Drinking water source	Municipality/ corporation	10	41.6%	14	58.4%	
	Well water	5	100%	0	0	
	Both	17	37.8%	28	62.2%	

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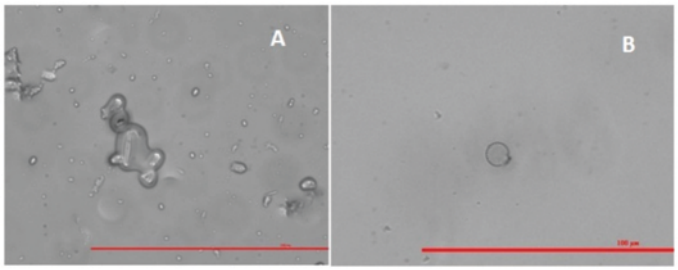

Figure : (A). Diatom of genus Navicula seen in the kidney - length 14.6 microns (1000 X)
(B). Diatom of genus Cyclotella found in the kidney - length 9.13 microns (1000x)

Table 3 : Average lengths of diatoms in kidney tissues

Length	Median length of diatoms (microns)	Length of smallest diatom (microns)	Length of largest diatom(microns)
Kidney (n=42)	16.054	9.396	21.067

The lengths of all the diatoms were measured using Image J software. In the kidney, the smallest diatom was 9.396 microns, and the largest was 21.067 microns in length (Table-3).

Table 4 : The types of diatoms found and their length.

Size	n	Mean	Standard Deviation	p-value
Pennate	39	16.535	4.398	**0.023**
Centrale	3	10.653	2.411	

The average length of pennates was 16.535 microns, and that of centrales was 10.653 microns (p-value-0.023) (Table 4).

vegetarians. Fourteen cases consumed corporation/municipality water, no cases which consumed well water alone, and 28 cases that consumed well water and corporation/municipality water both as their main source of drinking water (Table 2) (Fig1).

An attempt was made to identify the genera of the diatoms observed in the organs. Kidney contained predominantly Navicula (pennate). There were three cases having Cyclotella, and it was the only genus of centrale present in the kidney. Surirella, Diatoma, and Cymatopleura were the other genera of diatoms seen in the kidney.

Discussion:

Diatom test is routinely used by Forensic pathologists in cases of bodies recovered from water to identify the cause of death and the site of drowning. In those cases where the cause of death was uncertain, a thorough postmortem examination supported by a positive diatom test was found to play a vital role as evidence in the court of law.[11] The reliability of the diatoms test has always been a point of argument among Forensic pathologists worldwide. It depends on the exclusion of contaminant diatoms and the correct interpretation of results. This again involves a complete taxonomic analysis of the diatoms recovered from the putative drowning medium and those from the organs of the deceased person.[12] The possibility of diatoms entering the body through sources like food, water, and inhaled air cannot be ruled out.[13] They can remain in the body for a long period of time owing to the tough silica coating. These diatoms can be recovered from the tissues after death and demonstrated by various methods. Such diatoms are known as contaminant diatoms. By identifying just one or very few diatoms within the body, one cannot comment on the cause of death to be drowning. Only an expert will be able to differentiate contaminant diatoms (false positive cases) from drowning-associated diatoms (true positive cases).[4] The present study was done to identify the presence of diatoms in kidney tissues of persons who died due to causes other than drowning. If diatoms were present in these tissues, the possible sources of entry were studied and correlated. The diatoms were identified at the order level (centrales or pennates). For the convenience of analysis, four age groups were selected. The first group consisted of cases less than 30 years, the second group was between 31 and 45 years, the third group was between 46 and 60 years, and the fourth group was above 60 years. 57.1% of cases having diatoms in the kidney belonged to the ages above 46 years. As the age advanced, the exposure to contaminant diatoms also increased, and therefore their presence was found more in older age groups. This is in contradiction to a study that states that "Few as they are, diatoms also exist in the lungs of non drowned dead bodies of human adults, but there is no relation between the number of diatoms and their sexes, ages, or areas of the location."[14]

A total of 57.1% of non-vegetarians and 40% of vegetarians included in the study had diatoms in their bodies. This finding has been established in previous studies where raw fruits and vegetables have been identified as the source of soil diatoms. Non-vegetarian foodstuffs like fish, meat, and mollusks are also sources of diatoms (if not properly cleaned before cooking) which can enter the bloodstream by penetrating the intestinal lining.[15-16]

In those subjects where the only source of drinking water was corporation/municipality, there were 87.5% cases having diatoms. In those subjects where well water was the only source of drinking water, there were 80% cases with diatoms in at least one of the tissues and 84.44% cases where corporation/municipality and well water were both the main sources of drinking water. In the single case where purified drinking water was used for drinking, there were no diatoms in any of the tissues. In those cases where corporation/municipality and well water were all used as a primary drinking water source, there were a higher proportion of diatoms in the tissues. This is not in accordance with previous studies where the presences of diatoms in these sources are relatively few.[17] Statistical tests of significance for age and drinking water sources were not done since the number of cases was very few in some of the groups in these parameters. The relation of the other parameters (gender and dietary habits) to the presence or absence of diatoms in the individual tissue samples was found to have no statistical significance. This observation is supported by a study done previously, which has similar findings.[18]

Another interesting finding was that the centrales were found less

common than pennate type of diatoms. A significant finding was that the length of centrales within the tissues compared to the pennates was very small in all individual tissues. The smallest diatom seen within the tissue was of size 7.887 microns, and the largest measured 33.339 microns. The average length of the diatoms found in the body was 18.78 microns. Thus diatoms found inside the body are smaller in size compared to those found in water. Diatoms in water are 1 micron to 2 millimeters long.[17,19]

On average, in the study, an entire microscopy slide contained one diatom. This is a significant finding because the diatoms which have been identified in the non-drowning deaths are very few in number. The most common types of contaminant diatoms are of the pennate type, of which the genus Navicula was predominantly seen in all four organs examined. Of the centrale types of contaminant diatoms, the most common genus was Cyclotella. Other types of contaminant diatoms belonged to the genera Diatoma, Cymatopleura, Diploenis, Cocconeis, Nitzschia, Pinnularia, Surirella, and Stephanodiscus. Pollanen, in his monograph, has given a detailed description of these contaminant diatoms, which belong to the false-positive cases during diatom analysis in drowning. The present study has also proved the presence of these contaminant diatoms. Therefore, by the mere presence of diatoms, one cannot confidently conclude that death has occurred due to drowning. If the above-mentioned diatoms are seen during tissue examination for diatoms, the possibility of them belonging to contaminant types should always be considered before jumping to conclusions. Previous studies have shown that the most common types of diatoms seen in water bodies belonged to the genera Melosira, Pinnularia, Stauroneis, Synedra, Cymbella, Diatoma, Cyclotella, Surirella, Cocconeis, Naicula, Fragilaria, Stephanodiscus, Phaenodactylum, Chaetoceros, Pleurosigma, Cymatopleura, Diploenis, Gyrosigma, Coscinodiscus, Rhizosolenia etc.[19] Further studies are required to describe the most common types of diatoms seen in drowning-associated deaths, their sizes, and the relative proportion in which they enter the tissues. Only then, a complete and authentic report can be given by the forensic diatomlogist.

The outcome of the present study is that diatoms present in the kidneys of non-drowning cases are fewer in number and smaller in size. The genera of contaminant diatoms detected are limited to very few varieties like Navicula, Cyclotella, Diatoma, Cymatopleura, Diploenis, Cocconeis, Nitzschia, Pinnularia, Surirella and Stephano discus.

Conclusion :

The present study has revealed the presence of contaminant diatoms in the kidneys of persons who died of causes other than drowning. The possible sources of entry of such diatoms could be food and drinking water. The study has revealed that the contaminant diatoms are fewer in number (one diatom per slide) and smaller in size (smallest diatom was 7.887 microns; largest measured 33.339 microns; the average length was 18.78 microns). The most common genera of contaminant diatoms were Navicula of the order Pennate. The study establishes the fact that the mere presence of diatoms should not be the single criterion to confirm the cause of death. Diatoms in the kidneys should be comparable with the size, number, and genera found in the putative drowning medium.

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Ethical Clearance : Institutional ethical committee clearance was obtained before conducting the study.

Conflict of Interest : Nil

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ORIGINAL ARTICLE

Study of Forensic Age Assessment using Kvaal's Method with Digital Orthopantomographs (OPG)

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Abstract :

Age is one of the important factor in making the identity of a person. Anthropologists, Archaeologists and Forensic scientists determine the age for identity of a person. Kvaal and Solheim given a method used on adults for calculation of age with the help of morphological and radiological methods, but extraction was still required. Present study was an observational study under taken for forensic age assessment using Kvaal's method with digital orthopantomographs. In the present study out of 100 subjects, maximum number of subjects from age group of 20–29 (61), 43 were females and 57 were males. Coefficient of determination was highest for lower first premolar (0.517) followed by upper central incisor (0.178), lower canine (0.134), lower lateral incisors, upper second premolar and upper lateral incisors. M & W-Lwere found significant predictors for lower first premolar, lower canine and upper central incisors. Regression equation derived for combined upper three teeth & lower three teeth revealed that coefficient of determination (R2) was significant higher for lower three teeth (0.478) than upper three teeth (0.069) with M & W-L were significant predictor. Regression equation derived for all six teeth together shows significant coefficient of determination R2 (0.430) with M, W-L both are significant predictors. When all the six teeth taken together & compared for actual age & estimated age, mean difference was found to be (0.007). Kvaal's method for estimating age using digital orthopantomographs can be used for near accurate age estimation in 20-60 years age population with out removal of tooth.

Keywords : Forensic dentistry; Kvaal's method; Digital OPG; Age estimation.

Introduction :

Age is one of the important factor in making the identity of a person. Anthropologists, Archaeologists and Forensic scientists determine the age for identity of a person.[1] In crime solving, the age is determined from the teeth when external characteristics are not helpful.[2] Calculation of age is foremost important where documentary proof is not available or forged and to know the individual committed crime has reached the age of criminal responsibility.[3]

Age estimation of a person is important to confirm the legal issues in the field of employment, criminal offences and labor acts.[1] Teeth are very exclusive part of a person because they are long lasting and flexible part of the skeleton.[2] With increasing age, dental pulp undergoes reduction in size, due to secondary dentine deposition, so it can be used as an indicator of age. It can also be used as a parameter of age estimation even beyond 25 years of age.[4,5]

Kvaal and Solheim given a method used on adults for calculation of age with the help of morphological and radiological methods, but extraction was still required.[5] Hence to improve this procedure Kvaal et al suggested a method which is totally based on radiological analysis.[7]

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Bosmans et al,[7] modified the original Kvaal et al,[6] technique, which is used individual periapical X-rays, could also be applied to digital OPG's (orthopantomogram) taken. Author concluded that the regression formula derived from the original Kvaal et al study a can be applied to data obtained from digital OPG's.[7] In present study we have undertaken forensic age assessment using Kvaal's method with digital orthopantomographs at our medical college.

Material and Methods :

The present study was an observational study carried at Forensic Medicine Department of MMIMSR, Mullana and Oral Medicine and Radiology Department of MMCDSR, Mullana, Ambala. Study period was from November 2014 to April 2016 (18 months). Ethical clearance taken from IEC where the study was conducted.

Inclusion criteria :

- Subjects with all the required complement of teeth on either right or left side, which are free from morphological abnormalities and have completely erupted clinical crown of the said teeth in the oral cavity.
- The subjects should be able to produce an authenticated proof of date of birth preferably in the form of birth certificate.

Exclusion criteria :

- Subjects below 20 years of age with even one of the six required teeth missing or Impacted.
- Subjects with systemic disorders like hormonal deficiencies, renal diseases, blood dyscrasias, cardio-vascular diseases and

syndrome associated diseases.

- Subjects who failed to produce authenticated date of birth proof.
- Also, The teeth involved for the study were: carious/restored either in the crown or root or have prosthesis to it/have pulp stones or pulpal pathologies/malposed teeth/teeth with wasting diseases (attrition/abrasion/erosion) 100 cases in the age group of 20 to 60 years were selected by random sampling. The subjects were explained about the details of the study and the procedure in the language under stand able to them. A written informed consent was taken for participation.

Measurements were performed on the digital panoramic radiograph on six teeth i.e. maxillary central incisor, maxillary lateral incisor, maxillary second premolar, mandibular lateral incisor, mandibular canine and mandibular first premolar. The measurements were carried out on the orthopantomographs for all six types of teeth using dimax is digital software.

Measurements of maximum tooth length, pulp length and root length on mesial surface from cementoenamel junction to root apex, the pulp and root width at level a (CEJ), at level c (mid root length) and at level b (mid point between CEJ (a) and mid root length (c) was made. Ratios between the length and width measurements of the same tooth were calculated in order to avoid measurement errors due to differences in magnification of the image on the radiograph. The ratios calculated were: tooth/root length (T), pulp/root length (P), pulp/tooth length (R) and pulp/root width at three different levels a, b and c. Mean values of all ratios (M) as first predictor and mean value of width ratios from levels b and c (W); mean value of length ratios P and R (L) were calculated. The difference (W-L) is the second predictor.

After co-relation, regression analysis was carried out which helps to estimate change in one of the variables (Age) when there is a change in the others (M and W-L). The statistical software used was SPSS (V 23.1) and using this, various regression equations were derived to estimate the age of the subjects. The age for each of the subjects was calculated using these regression equations and compared with the actual age using the student's t-test. P-value less than 0.05 was considered significant.

Results :

In the present study out of 100 subjects, maximum number of subjects i.e. 61 were from age group of 20 – 29 and minimum number of subjects i.e. 7 were in the age group of 50 –59. 43 were females and 57 were males.

The regression equation for all six studied teeth and coefficient of determination R^2 was found for all the individual six teeth. Coefficient of determination was highest for lower first premolar (0.517) followed by upper central incisor (0.178), lower canine (0.134), lower lateral incisors, upper second premolar and upper lateral incisors. M & W-L were found significant predictors for lower first premolar, lower canine and upper central incisors.

Regression equation derived for combined upper three teeth & lower three teeth revealed that coefficient of determination (R^2) was significant higher for lower three teeth (0.478) than upper three teeth (0.069) with M & W-L were significant predictor.

Regression equation derived for all six teeth together shows significant coefficient of determination R2 (0.430) with M, W-L both are significant predictors.

When all the six teeth taken together & compared for actual age & estimated age, mean difference was found to be (0.007). No statistically significant difference between actual age and estimated age was noted in study subjects (p-value 0.994).

Discussion:

The aim of an ideal age estimation technique is to arrive at an age

Table 1 : Age & Gender distribution.

Age Group	No. of Patients	Percentage
20-29	61	61.0
30-39	16	16.0
40-49	16	16.0
50-59	7	7.0
Total	100	100.0
Sex		
Female	43	43.0
Male	57	57.0

Table 2 : Regression analysis for lower three teeth & upper three teeth.

Teeth	Equation	R2	Significant Predictors
Lowercanine	Age =46.86-76.31M-33.57W-L	0.134	M&W-L
Lower Lateral Incisor	Age = -11.23+ 132.83M +31.76W-L	0.057	NONE
Lower first Premolar	Age= 53.47-126.145M -63.98 W-L	0.517	M&W-L
Upper Second premolar	Age= 43.62-102.66M-55.46 W-L	0.044	M
Upper lateral incisor	Age = 41.08-9.72M+ 5.38W-L	0.033	NONE
Upper central incisor	Age = 41.84-130.96M-78.64W-L	0.178	M&W-L

Table 3 : Regression analysis for Combined upper and lower Teeth.

Teeth	Equation	R2	Significant Predictors
Upper three teeth	Age =54.85-137.89 M-62.48 W-L	0.069	M & W-L
Lower three teeth	Age = 42.84-216.2M-128.78W-L	0.478	M & W-L

Table 4 : Regression analysis for all six teeth.

Teeth	Equation	R2	Significant Predictors
All Six teeth	Age = 57.97-343.47M-194.34W-L	0.430	M & W-L

Table 5 : Comparison of estimated age with the actual age for all six teeth.

Tooth	Actual age		Estimated age		Mean Differenceta	T	p-value
	Mean	SD	Mean	SD			
All Six teeth	31.19	10.39	31.18	6.81	0.007	0.007	0.994

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as close to the chronological age as possible. In children and adolescents, somatic development, such as skeletal maturity, height, menarche etc. has been used to assess the age when unknown. Dental age estimation has gained acceptance because it is less variable when compared to other skeletal and sexual maturity indicators.

Demirjian method was employed keeping calcification of teeth and scoring system as the base of the study but had limited applicability only up to the age of 21 years.[8] A study based on the concept that with advancing age the size of pulp cavity is reduced because of secondary dentin deposit had been carried out in 1994 as an indicator of age by Kvaal et al in100 subjects, with the age limit of 20-60 years. The age of the subjects were estimated by Kvaal's method by using digital orthopantomographs.[9] Similar study done by Nathalie Bosmanetal on Belgian population.[7] In the present study the six teeth that were selected from both the jaws showed no significant difference in measurements between the teeth from the left and right side of the jaws, which is in consistence with the earlier study conducted by Kvaal et al.[9] In Kvaal's study, regression formula derived for all the six teeth together, substituting 'M and 'W-L' showed significant results with coefficient of determination being the strongest (R2= 0.76) but in our study, lower first premolar was the strongest predictor (R2=0.517).

When the calculated age was compared with actual age in Kvaal's study, they found no significant difference between the two when taking all six teeth together and mandibular three teeth together (P>0.05), which is similar to our study. In our study coefficient of determination for all the six teeth taken together (0.430) and lower (mandibular) three teeth (0.478) is almost similar. Further in Kvaal's study they found a significant difference between the calculated age and the actual age when taking maxillary three teeth together or each of the six teeth individually. But in our study, we got no significant difference between the two when taking maxillary three teeth together or each of the six teeth individually (P>0.05).

Landa et al[10] applied. Kvaal's to direct digital OPG's. The author found that when measurements were applied to both the Kvaal's et al and Paewinsky et al[4] standards, both standards consistently over estimate actual age by 14.80 years and 20.9 years respectively. Landa et al concluded that the Kvaal's et al standard cannot be applied to direct digital OPG's and cannot be considered as an authentic sign for calculation of age using direct digital OPG's. The difference between the results obtained in Kvaal et al 1995 and Landa et al may be because the latter only assessed the three mandibular teeth instead of six considered in the original study.

The difference in the results obtained could be explained on the fact that the software used to measure in Kvaal's technique on digital orthopantomographs was Adobe Photoshop (version 7.0) but in the present study, we used Dimax is software as the measurement tool. The other reason could also be because of the racial difference as the original study was carried out on Caucasian population and our study was based on the Asian population.

In our study, we have used digital orthopantomographs for assessment of age, whereas study by Kvaal et al[9] used the intraoral periapical radiographs and Nathalie Bosman et al[6] used orthopantomographs for obtaining the regression formula. Orthopantomographs were selected in this study because of the possibility of the evaluation of all teeth along with alveolar bone in both jaws, several measurements can be performed on the same x-rays. Furthermore, orthopantomograph is a standard technique with high reproducibility, while the acceptability of intraoral radiographs is dependent on the techniques used and the practical training of the personnel. From the comparison of actual age and estimated age given above we observe that there is no significant difference between the mean actual age and the mean estimated age in lower canine, lower lateral incisor, lower first premolar, upper second premolar, Upper lateral incisor, Upper central incisor, upper three teeth when taken together, Lower three teeth when taken together and all the six teeth taken together.

Conclusion :

Orthopantomography (OPG) is a standard technique for oral radiographic evaluation. Kvaal's method for estimating age using digital orthopantomographs can be used for near accurate age estimation in 20-60 years age population without removal of tooth.

Conflict of Interest : None to declare

Source of funding : Nil

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ORIGINAL ARTICLE

Profile of Poisoning cases in North west region of Haryana- A Retrospective study at a Tertiary care Hospital

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Abstract :

Poisoning is one of the major medico legal problem for physicians. Present study is conducted to know the profile of poisoning cases. A four year (January 2017 to January 2021) retrospective study of acute poisoning cases is conducted from the patient's record to know the trends of poisoning. 60% cases were from males. The peak age group was 21 to 30 years. Rural residence has dominated. Most of victims consumed poison in their home, which came to hospital after one hour of consumption. Poisoning cases decreases in year 2019 and suddenly jump in year 2020 due to Covid pandemic. Most of cases occur on Tuesday in summers in the month of June. OPC (50.7%) is the common poisonous agent followed by Aluminum phosphide (34.7%). The least common poisons are corrosives and kerosene. Aluminum phosphide more frequently used in suicidal attempts.

Keywords : Poisoning; OPC; Aluminum phosphide; Covid pandemic.

Introduction :

History of poisoning is as old as history of mankind. Its trend changes from time to time and country to country. In the last decade or so owing advancement in the field of agriculture, medical pharmacology and industry in India there is significant change in the trend of poisoning.

It is reported that between 1972 and 1977 the Barbiturates and copper sulfate were the most common poisons, between 1977 and 1982 the organophosphates became the most common and Since 1982, Aluminum phosphide is leading.[1]

Vulnerable age group for poisoning is 18-35 years. Intentional poisoning is more common than accidental. Poisoning due Household poisons is more common than Agricultural pesticide group.[2]

To know the pattern of poisoning in any region the data of diagnosed non-fatal acute poisoning is required in comparison to fatal poisoning of that area. For non fatal poisoning the treating physician determine the toxic agent for hospitalization.[3]

Present retrospective study is carried out to view the change in poison trend in North West region Haryana, so that prevention and regulation measures should be taken by appropriate authorities.

Material and Methods :

Study design :

This retrospective study was conducted to see trend of poisoning in northwest region of Haryana. The study period was conducted between January 2017 to December 2020. Medical record was evaluated retrospectively. Because the study involved record review and no data were collected directly from individuals, no consent was required. To ensure confidentiality, patient names were replaced by codes, which were used as identifiers in data analysis. Ethical approval was secured from the Ethical committee Adesh medical college (Ref. No. / AMCH/IRC/21/012 Dated 27.1.2021).

Study Population :

All poisoning cases admitted to the emergency department of Adesh Medical College & Hospital, which is tertiary care center with superspeciality services and bed strength of 600 well equipped with modern diagnostic and treatment facilities.

Data Collection :

A standardized Data collection sheet is used to collect the data of the victims according to their age, sex, marital status, occupation, the name of poison taken, date and time of consumption, reason, route, day, month, year, place, brought by, time of admission in the hospital and outcome with duration of stay in hospital and a retrospective survey was performed.

Inclusion criteria:

All patients coming to emergency with history of poisoning, symptoms and signs of poisoning were included.

Exclusion criteria:

Patients with snake bite, scorpion bites, and unknown bites, idiosyncratic reaction to prescribed drugs, food poisoning, and pregnant woman were excluded from this study.

Statistical Analysis :

Data collected was entered into a spreadsheet of Microsoft excel 2007. Data collected were analyzed using statistical software IBM SPSS statistics data editor. Descriptive Statistics included frequency, percentage, mean and standard deviation.

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Results :

The study sample is 75 cases of poisoning presenting to the Emergency department during the four-year period. The mean age of the sample of poisoned patients was 28.36±13.73 years (Figure No 1). Males (60%) were predominantly present in this study. The females were 40% (Table No 1). In terms of age groups, most of our victims were young, 4% cases were below 10 years followed by 20% cases in 11-20 years, 45% were under 21-30 years, 17% were in of age 31-40 years. As the age increases the number of cases starts decreasing as 4% cases in 41-50 years, 7% in 51-60 years and no case reported from age group 61-70 years (Table No 2). According to residence the majority of patients were rural patients (89.3%) (Table No 3). On further analysis regarding marital status of victims, 58.7% cases were found to be married and 41.3% were single (Table No 4). In our study the most of victims were Farmers (40%). The distribution for other occupation was student (30.7%), Homemaker (22.7%) and Business (6.7%) (Table No 5). Seasonal variation of the patients was as summer (65%), winter (18.7 %,), autumn (9.3%) and spring (6.7%) (Table No 6).

On analyzing the accessibility to poisons it is found that most of victims consumed poison at their home (73.3%) (Table No 7). About 60% of them came to hospital after one hour of

Table 1 : Gender distribution.

Variable	Frequency	Percentage
Male	45	60
Females	30	40

Table 2 : Shows Distribution of cases According to age Groups.

Variable	Frequency	Percentage
0-10 years	3	4
11-20 years	15	20
21-30 years	34	45
31-40 years	13	17
41-50 years	3	4
51- 60 years	5	7
61-70 years	0	0
71-80 years	2	3

Table 3 : Residential Distribution.

Variable	Frequency	Percentage
Rural	67	89.3
Urban	8	10.7

Table 4 : According to Marital status.

Variable	Frequency	Percentage
Married	44	58.7
Single	31	41.3

Table 5 : Occupational Distribution.

Variable	Frequency	Percentage
Farmer	30	40
Student	23	30.7
Housewife	17	22.7
Business	5	6.7

Table 6 : Seasonal Distribution.

Variable	Frequency	Percentage
Winter	14	18.7
Spring	5	6.7
Summer	49	65.3
Autumn	7	9.3

Table 7 : Place of Occurrence.

Variable	Frequency	Percent
Farm	8	10.7
Home	55	73.3
Market	12	16.0

Table 8 : Time of arrival in hospital after poisoning.

Variable	Frequency	Percent
Within hour	30	40.0
After one hour	45	60.0

Table 9 : Brought By.

Variable	Frequency	Percent
Police	1	1.3
Relative	52	69.3
Friends	20	26.7
Self	2	2.7

Table 10 : Time of Admission in Hospital.

Variable	Frequency	Percent
Morning (4A.M to 12 PM)	18	24.0
Afternoon (12 PM to 6 PM)	26	34.7
Evening (6 PM to 8 PM)	16	21.3
Night (8PM to 4AM)	15	20.0
Total	75	100.0

Table 11 : Duration of stay in the Hospital.

Variable	Frequency	Percent
< 1 day	40	53.3
1 day	12	16.0
2 days	12	16.0
3 days	5	6.7
>3 days	6	8.0

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Table 12 : Outcome.

Variable	Frequency	percent
Discharged	64	85.3
Death	11	14.7

Table 13 : Distribution of case according to day, month and year.

Variable	Frequency	Percentage
Month		
Jan	8	10.7
Feb	2	2.7
Mar	3	4.0
Apr	8	10.7
May	9	12.0
June	12	16.0
July	7	9.3
Aug	6	8.0
Sep	6	8.0
Oct	6	8.0
Nov	2	2.7
Dec	6	8.0
Total	75	100.0
YEAR		
2016	11	14.7
2017	29	38.7
2018	18	24.0
2019	2	2.7
2020	15	20.0
DAY		
Monday	12	16.0
Tuesday	16	21.3
Wednesday	11	14.7
Thursday	8	10.7
Friday	8	10.7
Saturday	11	14.7
Sunday	9	12.0

Table 14 : Motive.

POISON		Stupefying	Suicidal	Homicidal	Unintentional	Total	Percent
	OPC	0	21	1	16	38	50.7
	Aluminum Phosphide	1	22	0	3	26	34.7
	Drugs	0	1	0	2	3	4
	Corrosives	0	1	0	0	1	1.3
	Alcohol	0	0	0	2	2	2.7
	Naphthalene	0	0	0	0	2	2.7
	Phenyl	0	2	0	0	2	2.7
	Kerosene	0	0	0	1	1	1.3

Table 5 : Route.

	Oral	Inhalation	Dermal	Total
OPC	31	6	1	38
Aluminum Phosphide	26	0	0	26
Drugs	3	0	0	3
Corrosives	1	0	0	1
Alcohol	2	0	0	2
Napthalene	2	0	0	2
Phenyl	2	0	0	2
Kerosene	1	0	0	1
Total	68	6	1	75

consumption (Table No 8). Most of the victims who came to emergency were brought by their relatives 69.3% (Table No 9). The maximum number of victims admitted in afternoon (34.7%) (Table No 10). The duration of stay in hospital was less than one day to more than three days but mostly victims discharged within one day (53.3%) (Table No 11). Recovery rate was high as only 14.7% of victims died from poisoning (Table 12).

On further analysis of daily distribution and monthly distribution of cases, most of victims of poisoning came on Tuesday (21.3%) and in the month of June (16%). On Thursday (10.7%) and Friday (10.7%) cases were less as compare to other days. Covid pandemic came to India in the year 2020 which has lead to instability of life and lead to increase in cases in year 2020 when compared to 2019 (Table No 13).

The distribution of poisonous agents shows that the first most common agent is of OPC (50.7%) poisoning. Second most common agent consumed was the Aluminum phosphide (34.7%). Drugs were consumed by 4%, alcohol by 2.7%, Naphthalene by 2.7%, Phenyl by 2.7%. The least common agents were Corrosives (1.3%) and Kerosene (1.3%) (Table No 14). On investigation for reason for consuming the poison it is detected that Suicide was main motive for poisoning and Aluminum phosphide was most commonly used to commit suicide (Table No 14). The most common route was oral (Table no 15).

Discussion:

Pattern of poisoning help the hospital in resource allocation. It detects the vulnerable age group, conditions responsible and individual susceptibility. For a Forensic Medicine expert, the acute poisoning in young person can be suicidal, homicidal or accidental. Change in trend of poisoning can also affect the medico legal outcome. Self-poisoning may be thought as stress indicator for youths. In the present study we have found that there is male predominance which is similar to other studies, Chaitanya Kumar and Patil interviewed the 59 cases and found that stress due family conflicts and high expectation pushing males for taking poison as extreme step.[4] Arvinda V et al conducted research of association of poisoning, snake bite and drug over dosage with demographic variables and found that males more

susceptible to poisoning and females more prone to drug over dosage.[5] Karki and Risal in Nepal found male preponderance.[5] Male outnumbered females in study conducted in North India by Sharma et al.[7,8] Similar results found in other parts of India as, in Andhra Pradesh,[9] in Karnataka,[10] in Orissa,[11] in Bengaluru,[12] in Manipal region of southern India.[13] However in one study from Chennai, South India female predominance is seen due to abuse of woman along with family burden.[14] In western countries Female preponderance is present.[15,16] In Sri Lanka males prefer Agrochemicals in non- fatal poisoning and females prefer pharmaceuticals.[17]

In the present study third decade is more susceptible to poisoning. This is period of stress, competition, expectation.[3, 6, 10, 11] In South Africa and UK the common age is 20 to 29 years, In USA the age group of susceptibility is 15 to 19 years.[15,16,17] Poisoning case presentation is affected by the marital status of a person. We found that married persons are more prone to poisoning. Dash et al concluded that stress of day to day life is responsible for it.[11] Similar results are from Nepal.[6] Srihari et al found that three to seven years of marriage are prone to poisoning and they found that incidence of poisoning is minimum in persons with 25 years

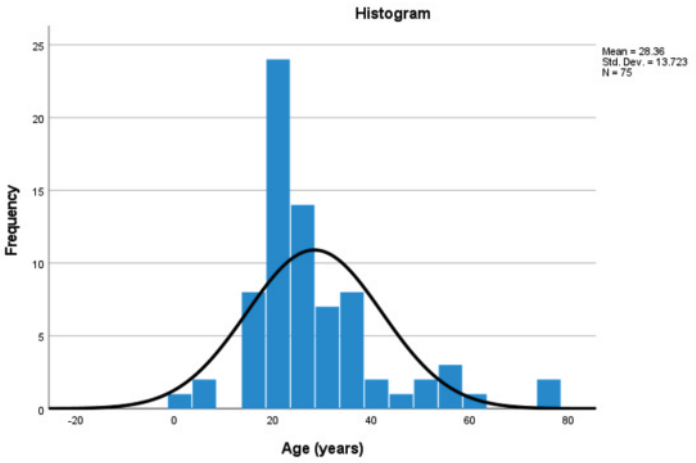

Figure 1. Distribution of age groups.

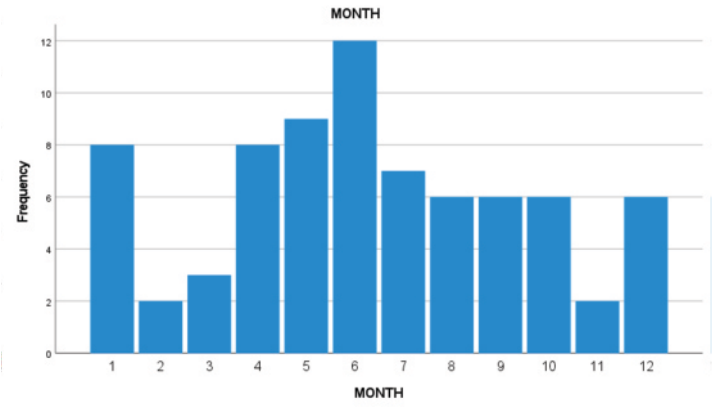

Figure 2 : Shows monthly distribution of cases.

of marriage.[14] Avsarogullari et al in study from Turkey also found that married persons are more prone to poising than single.[18] Season also plays important role in mental status of a person. We found more case in summer season. The poisoning in summers due to long sunny days, fatigue and exhaustion.[11,9,19] In south India Srihari et al found maximum cases in Monsoons.[14] Present study shows that Number of cases increases in the month of April, May and June. In south Africa the majority of cases are in February and April.[15] Suicide death increase in spring season.[20,21]

In the present study the OPC and Aluminum phosphide are leading cause of poisoning. In our study 50.7% cases of OPC poisoning and 34.7% cases of Aluminium phosphide. Similar results were found in the other parts of India and other developing countries.[5,19,14,22,23,24] In year 2019 in New Delhi the corrosives were most common agent of poisoning.[25] In south Africa most common agent of poisoning is Paracetamol drug.[15] Bjornaas et al found that the toxic agent for non-fatal poisoning was ethanol, opiates and benzodiazepines.[3] In Iran pharmaceutical drugs are most commonly used for self-poisoning followed by opioids which are followed by pesticides. In Iran benzodiazepines are available without prescription which is major factor for poisoning.[26] Gunnell et al described global distribution of fatal pesticide poisoning, they have noted that in terms of sale Europe has 29% of world market of pesticides and it has only 2% of pesticide suicides whereas Asia has 25% of world market but it has 91% of deaths. They found that Canada has no data of suicides by pesticides; in North America pesticides are rarely used. According to them Aluminium phosphide is frequently used for suicide in North India. They reviewed the various studies and showed that suicides rate of 60 per 100,000 in Tamil Nadu whereas it is 40 per 100,000 in other parts.[27] Most of the episodes of poisoning occurred in the evenings in our study.

Summary and conclusions :

OPC and Aluminum Phosphide are most common poisons encountered in emergency admissions. Deliberate self-poisoning is most common in adult married males who are in third decade of life. Most of cases occur at home in the evening of summer months by oral route. Most of incidences occur on Tuesday and in the evenings.

Declaration on Conflict of Interest : Nil

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Ethical Clearance :

Has been obtained.

Source of Funding : Nil

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ORIGINAL ARTICLE

Study of Fingerprints in Relation to ABO Blood Groups and Gender

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Abstract :

The present study was done evaluate the correlation between fingerprint pattern and ABO blood group and correlation between fingerprint pattern and gender. Both blood group and dermatoglyphic pattern have genetic inheritance so an attempt has been made to analyze their correlation with gender and blood group of an individual. A prospective study was conducted on medical students among whom 120 students were selected for the study, (60 male and 60 female) between the age group 20- 25, any hand deformities and any extra fingers were excluded from the study. The distribution of dermatoglyphic patterns in both hands of individuals and its relationship with gender and different ABO and Rh blood groups was analysed. There were 42.5 % subjects with B blood group, 27.5% with A blood group, 17.5% with O blood group and 12.5% were having AB blood group. There was a significant association between fingerprint pattern with ABO blood groups ($p<0.05$). Whereas no significant association between fingerprint pattern and gender was seen. The study concluded that there is a significant association between fingerprint pattern with ABO-Rhesus blood groups and ABO blood groups while there is no significant association between fingerprint pattern with gender.

Keywords : ABO Blood Group, Fingerprints, Dactylography, Dermatoglyphics, Rh-Hr Blood-Group System, Gender.

Introduction :

The skin of the palms and soles is marked by a carved ridge and study of the pattern of these ridges on the fingers is called dermatoglyphics.[1] Dermatoglyphics has been used since ancient times as a diagnostic aid and now it is well established in number of diseases which have strong hereditary basis and is employed as a method for screening for abnormal anomalies. Fingerprint minutiae patterns of ridges are determined as unique through the combination of genetic and environment factors. Fingerprint patterns have been normally used for identification of an individual.[2] Finger prints are frequently used in forensics as proof of identity and acts as strong circumstantial evidence for crime investigations.[3]

Human fingerprints fall into three main groups: loops, whorls and arches.[4] When one or more than one ridge enter from one side of the pattern and recurve to exit from the same side of point of entry, it forms a loop. Loop is further classified into radial and ulnar based on the manner of slope of the fingerprint pattern. Whorl constitutes two deltas and minimum one ridge forming a complete circle which can be spiral, oval, circular or any variety of a circle. The different patterns of whorls include the plain whorl, central pocket loop, the double loop and accidental whorl. Arches are the simple but a rare pattern. This fingerprint pattern has ridges running from one side to the other side of the print without having any re-curve. Sub types of arches are the plain arch and the tented arch.[5] One more group of fingerprints which is combination of two or more types (Loops, Arches, or Whorls) is grouped as Composite type of fingerprint.

Blood group system was discovered way back by Karl Landsteiner in 1901. Later "Rhesus" system was defined by Landsteiner and Wiener in 1937. Clinically, only "ABO" and "Rhesus" groups are of major importance. "ABO" system is further classified as "A," "B," "AB," and "O" blood groups according to the presence of corresponding antigen on red blood cells. "Rhesus" system is classified into "Rh +ve" and "Rh −ve" according to the presence or absence of "D" antigen.[6]

As fingerprint pattern remains same throughout the life and considering the fact that no two individuals have similar pattern, dermatoglyphic study is recognised as the most reliable, convenient and acceptable method of individual identification.[7] Both blood group and dermatoglyphic pattern have genetic inheritance so an attempt has been made to analyze their correlation with gender and blood group of an individual. For adding more clarity to existing literature this study was carried out with the aim of evaluating the correlation between fingerprint pattern and ABO blood group and correlation between fingerprint pattern and gender.

Methodology :

Present prospective study was conducted among medical students of a medical college located in Kolhapur. Total 120 students (60 male & 60 female) between the age group 20- 25 years were selected who were voluntarily participated in the study. Informed consent was taken after clearly explaining the objective and procedure of the study. Subjects with permanent scars on fingers, with any hand deformities due to injury, birth defect, or disease, those having worn finger-prints, extra finger, or

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webbed fingers, were excluded from the study since it would alter the statistical outcome.

Each subject was asked to wash the hands thoroughly with soap and water and dry them using a towel. This was done to remove dirt or any foreign materials from fingertips. He/she was then asked to press his/her fingertip lightly on the stamp pad and then to the paper to transfer the fingerprint impression. The same method was repeated for all the fingers of both the hands. Care was taken to avoid smudging of the prints. Details such as age, sex and blood group were noted. The fingerprint patterns were studied with the help of a magnifying lens and further divided as: loops, whorls, arches and composites. The distribution of dermatoglyphic patterns in both hands of individuals and its relationship with gender and different ABO and Rh blood groups was analysed statistically.

Statistical Methods :

Data was analyzed using statistical software R 3.6.3 and Excel. There were 120 subjects in the study. Chi square was performed to check the association between two categorical varaibles. Categorical variables are represented by frequency table. A p-value less than or equal to 0.05 was considered statistically significant.

Results :

Total 120 subjects participated in the study and Male to female ratio was 1:1 between the 20-25 years of age group. There were 42.5 % subjects with B blood group, 27.5% with A blood group, 17.5% with O blood group and 12.5% were having AB blood group (Table 1). Loops were the most common fingerprint pattern observed by both genders. There was no significant association between Fingerprint pattern with gender. ($p>0.05$) (Table 2).

B+ blood group observed highest followed by whorls, arches, Loops and composites. Whorls were least seen in AB-, lowest number of arches and loops were recorded in O- and no Composite were observed in A-, AB-, B- and O-. There was a significant association between fingerprint pattern with ABO-Rhesus blood groups. ($p<0.05$) (Table 3).

Whorls, Arches, Loops and Composite were more prominent in AB blood and seen least in B blood group. There was a significant association between fingerprint pattern with ABO blood groups.

Table 1: Descriptive statistics for categorical variables.

Variables		Frequency	Percentage
Sex	Female	60	50
	Male	60	50
Blood group	A-	3	2.5
	A+	30	25
	AB-	3	2.5
	AB+	12	10
	B-	4	3.33
	B+	47	39.16
	O-	1	0.83
	O+	20	16.66
Blood group	A	33	27.5
	B	51	42.5
	AB	15	12.5
	O	21	17.5

Table 2: Distribution of fingerprint pattern with regards to gender.

Fingerprint pattern	Female n (%)	Male n (%)	P value
Whorls	177 (48.36)	189 (51.63)	0.143
Arches	75 (58.13)	54 (41.86)	
Loops	336 (48.97)	350 (51.02)	
Composite	12 (63.15)	7 (36.84)	

Table 3: Ditribution of fingerprint pattern with regards to ABO-Rhesus blood group.

Blood groups	Whorls n (%)	Arches n (%)	Loops n (%)	Composite n (%)	P value
A-	7 (1.91)	2 (1.55)	21 (3.06)	0	0.001*
A+	102 (27.86)	29 (22.48)	166 (24.19)	3 (15.78)	
AB-	5 (1.36)	6 (4.65)	19 (2.76)	0	
AB+	30 (8.19)	4 (3.1)	84 (12.24)	2 (10.52)	
B-	21 (5.73)	4 (3.1)	15 (2.18)	0	
B+	136 (37.15)	51 (39.53)	273 (39.79)	10 (52.63)	
O-	8 (2.18)	0	2 (0.29)	0	
O+	57 (15.57)	33 (25.58)	106 (15.45)	4 (21.05)	

*p-value 0.05 statistically significant

Table 4: Ditribution of fingerprint pattern with regards to ABO blood group.

Blood groups	Whorls n (%)	Arches n (%)	Loops n (%)	Composite n (%)	P value
A	109 (29.78)	31 (24.03)	187 (27.26)	3 (15.79)	0.04*
B	35 (9.56)	10 (7.75)	103 (15.01)	2 (10.53)	
AB	157 (42.89)	55 (42.64)	288 (41.98)	10 (52.63)	
O	65 (17.75)	33 (25.58)	108 (15.74)	4 (21.05)	

*p-value 0.05 statistically significant

Table 5 : Distribution of ABO-Rhesus blood group with regards to gender.

Blood groups	Female	Male	P value
A-	1 (1.66)	2 (3.33)	0.74
A+	16 (26.66)	14 (23.33)	
AB-	2 (3.33)	1 (1.66)	
AB+	8 (13.33)	4 (6.66)	
B-	1 (1.66)	3 (5)	
B+	21 (35)	26 (43.33)	
O-	1 (1.66)	0	
O+	10 (16.66)	10 (16.66)	

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($p<0.05$) (Table 4).

Both the genders had more subjects with B+ blood group. There was no significant association between ABO-Rhesus blood group with gender. ($p>0.05$) (Table 5). AB blood group was found to be the highest among both the genders. There was no significant association between blood group with gender. ($p>0.05$) (Table 6).

Table 6 : Distribution of ABO blood group with regards to gender.

Blood groups	Female	Male	P value
A	17 (28.33)	16 (26.66)	0.43
B	10 (16.66)	5 (8.33)	
AB	22 (36.66)	29 (48.33)	
O	11 (18.33)	10 (16.66)	

Discussion :

Fingerprint patterns are unique for every individual and thus have still been a gold standard for identification of an individual. This study was performed to see correlation between fingerprint pattern and aspects like gender and blood group. In the present study there were 33 subjects with A blood group, 51 with B blood group, 15 with AB blood group and 21 were having O blood group. While Desai et al., found that majority of the subjects in their study belonged to the blood group B i.e. 74 (37%) followed by O, 70 (35%), A, 42 (21%) and AB, 14 (7%).[8] In a study conducted Narayana et al., whorls and arches were more common in females (51.6%,51.8%) while loops were common in males (51.23%) and composite were equal in both genders. Loops were predominant in all the blood groups except A+ where whorls were dominant.[9] In the present study whorls and loops were more common in females while in males, loops were more in number. In contradiction loops were only seen in 0.3% of study group in O negative blood group and was dominant in others. In the present study, there was no significant association between gender and fingerprint pattern ($p=0.143$). The results coincide with the other studies, ($P > 0.05$) while some studies found that fingerprint patterns can be of help in predicting the gender.[10-12]

In the present study there was a significant association between fingerprint pattern with ABO blood groups ($p=0.04$). Some studies showed the similar results while a single study Ranjan et al, found that there was not any significant association found in between fingerprint patterns and ABO blood group. ($P > 0.05$).[11-17] Similar results were found by Eboh et al. who found significant association between fingerprint patterns and Rhesus blood group ($P < 0.05$).[10]

Study by Shreshtha et al, found that there was no significant association between gender, blood group and dermatoglyphic pattern. Hence it can be concluded that the prediction of blood group and gender may not be possible with the study of fingerprint patterns.[7]

In several study it was found that majority of subjects belongs to Rh-positive and O blood group, Loops are the most frequent patterns and arches are the uncommon patterns of fingerprint observed. Loops were highest in B blood group and lowest in AB blood group, whorls were highest in male and lowest in female. Loops were highest in Rh-positive and lowest in Rh-negative. Arches were highest in Rh-positive and lowest in Rh-negative[11-17]. All these results were similar to the present study while the researchers from the study found whorls highest in A and lowest in B blood group, Arches were highest in AB and lowest in B blood group, Loops were higher in female and lowest in male, and arches were highest in male and lowest in female. Whorls were highest in Rh-negative and lowest in Rh-positive which was opposite to the current finding.[18]

Conclusion :

The study concluded that there is a significant association between fingerprint pattern with ABO-Rhesus blood groups and ABO blood groups while there is no significant association between fingerprint pattern with gender, and blood group with gender. This study only included students from southern Maharashtra, hence more similar studies are necessary to search association between the fingerprint pattern and gender and blood group in other parts of the country.

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ORIGINAL ARTICLE

Conflict of Interest, Perception, Attitude, and Awareness in dealing with Ethical and Legal Issues in Medico-legal Cases among Healthcare Professionals and Public in a Tertiary Care Hospital

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Abstract :

Medical ethics, attitude, communication, and medical jurisprudence are closely related but not synonymous. Healthcare professionals must be aware of the legal aspects associated with their profession and take measures needed to protect themselves from legal traps. The objective of this study was to estimate the awareness, perception, attitude, and Conflict of interest of healthcare workers and the public concerning medico-legal cases (MLC). The secondary objective was to find an association between awareness and attitude among healthcare professionals and the community.

A cross-sectional study was conducted between 01st April to 31st May 2021 in a Medical college at Barabanki. The study was conducted among 167 participants, 106 (63.5%) were female, and 61 (36.5%) were male. The overall awareness about medico-legal issues was below adequate in 52.1% of respondents.

The study results revealed that the perception of people is affected by awareness and attitudes are influenced by personal interest. The study found a significant difference between the awareness and attitude of participants regarding medico-legal issues. It may be possible due to the usual awareness–attitude gap among the participants and the overall perception of the participants because the findings are not as expected. It needs to be improved through interactions between health care professionals and the public.

Keywords : Medico-legal issues; Conflict of interest; Perception; Attitude; Healthcare professionals.

Introduction :

Medical Ethics, attitude, communication, and medical jurisprudence are closely related, but are not synonymous. Morality is mainly derived from religious percepts and practices, therefore, is not open to logic and argument. Not following moral principles might result in the feeling of guilt and invite censure from society. Ethics are intellectually derived by a specific group or profession for its specific needs and could be changed or modified with change in situation.[1] There has been growing anxiety both within the medical profession and society regarding increasing trends of complaints and lawsuits against physicians.[2] It is therefore necessary for doctors to be aware of the legal aspects linked to their profession and take the necessary measures to protect themselves from legal traps.

In a developing country like India, rising discord between patients and doctors and dissatisfaction among patients have been observed. The frustration on the part of patients could partly be due to the lack of facilities, scarcity of funds, and lack of communication at all levels of medical care. Other points of view, the lax attitude of doctors in general, not following standard protocols, worldly mind set, and low ethical and moral standards are mainly responsible for legal problems and bringing ill repute to the health care system. Lawsuits can be avoided by taking steps to keep patients informed, adhering to policies/procedures, and developing patient-centric care with in available resources together with, knowing ways of defending against medical negligence allegations.

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Aim and objectives:

1. To estimate the awareness, perception, attitude, and Conflict of interest among healthcare professionals and the public concerning medico-legal cases.

2. To find an association between awareness and attitude among healthcare workers and the public in the community.

Material and Methods :

A cross-sectional study was conducted between 01st April to 31st May 2021 in a medical college at Barabanki to estimate the awareness, perception, attitude, and Conflict of interest among healthcare workers and the public concerning medico-legal cases and to find an association between awareness and attitudes. Pre-tested and validated questionnaires with four parts were used having equal weightage for each domain. The awareness and attitude sections in the questionnaire were given scores.

Inclusion criteria: Age above 18 years.

Exclusion Criteria: Incomplete questionnaires and no consent were excluded from the study.

Table 1. Socio-demographic characteristics of participants (n=167).

Characteristics	Category	Frequency (n)	Percentage (%)
Age (in years)	<30	133	79.6
	⩾ 30	34	20.4
Gender	Male	61	36.5
	Female	106	63.5
Designation	Doctors	50	29.9
	Paramedics	47	28.1
	Public	47	28.1
	Patients	23	13.9

Responses have been summarized and discussed in four parts (Domains).

Table 2 : Awareness of participants regarding Ethical & legal issues in medico-legal cases (MLC) (n=167).

Question	Response	Frequency (n)	Percentage (%)
Who decides whether a case is a medico-legal case (MLC)?	Injured person	13	7.8
	Relatives	0	0
	Police	39	23.4
	Doctor	115	68.8
Permissible blood alcohol concentration limit as per Motor vehicle Act 1988	50gm%	17	10.2
	80gm%	27	16.2
	30gm%	98	58.7
	15 gm%	25	15.0
Dowry's death is investigated by	Police	58	34.7
	Executive Magistrate	52	31.1
	Judicial Magistrate	43	25.7
	Public Prosecutor	14	8.4
The doctors can be punished for medical negligence in a criminal court up to	Life imprisonment	31	18.6
	Up to 2 years with or without fine	101	60.5
	Compensation up to any amount	8	4.8
	From 7-20 years imprisonment & fine	27	16.2
A couple can opt for Assisted Reproductive Technology after how many years of unprotected sex	6 months	67	40.1
	5 years	47	28.1
	Depending on the age of the Husband	19	11.4

Table 3 : Replies of participants towards conflict of interest in dealing with MLC in a Tertiary Care Centre.

Question	Response	Frequency (n)	Percentage (%)
Reason for not getting MLC registered fora relative injured after assault by the neighbor.	Harassment by Police	63	37.7
	Delay in settling cases	60	35.9
	Lack of money	18	10.8
	Opposition more powerful	26	15.6
What will you do if, for the occasional headache, a private practitioner advises you to get MRI done by a particular Radiologist?	Get MRI done by the same radiologist	44	26.3
	Seek MRI done by other radiologists	16	9.6
	Seek the opinion of Neuro	104	62.3
	physician/ Neurosurgeon		
	Ignore Medical advice	3	1.8
If a mentally ill person brought to a Private clinic injures another patient seriously, who should be punished for injury?	Mentally ill person	26	15.6
	The patient injured	7	4.2
	Doctor & staff of the clinic	48	28.7
	None	86	51.5
What can be a valid ground for divorce?	The spouse did second	45	26.9
	marriage Spouse is sterile	51	30.5
	Spouse develops cancer	9	5.4
	Desert's spouse for more than 2 years.	62	37.1
If 20 years old girl was raped after administering an intoxicating substance and then brought to the gynecologist in a drunken condition, the parent's consent is unobtainable, what should Doctor do?	Ask patient to be taken to some other Doctor	7	4.2
	Ask the Police to get a court	33	19.8
	order for examination Ask the girl to be brought the next day for examination	16	9.6
	Examine the patient to preserve evidence and give urgent treatment	111	66.5

Data Analysis:

Data were entered into a Microsoft excel sheet and analyzed using SPSS version 26. Data were summarized using Frequency and percentages with a confidence level of 95%. Chi-square tests were applied to find out the difference in proportions between overall awareness and inclusive attitude among participants.

Results and Discussion :

There was a total of 167 participants in the survey, of which 50 (29.9%) were doctors, 47 (28.1%) paramedics, 47 (28.1%) public, and 23 (13.9%) patients. 133 (79.6%) were in the age group of <30 years and 34 (20.4%) in the age > 30 years, out of 106 (63.5%) were female, 61 (36.5%) were male as shown in Table 1.

Most of the participants 115 (68.8%) were aware that the doctor decides whether the case was a medico-legal case or not as shown in table 2. A MLC is a case of injury/illness where the attending doctor, after taking history and examining the patient, thinks that some investigation by law enforcement agencies is essential to establish the causes and fix responsibility for the case by the law of the land.[2]

98 (58.7%) respondents knew about the Permissible blood alcohol concentration limit as per the Motor vehicle Act 1988 is 30 gm%.[3]

In the dowry death investigation, 58 (34.7%) participants didn't know the correct legal position and replied that the investigation is conducted by a police officer. However, a substantial number 52 (31.1%) have the right answer as executive magistrate.[4]

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Table 4 : Perceptions of participants regarding ethical & legal issues in MLC (n=167).

Question	Response	Frequency (n)	Percentage (%)
Would you like an autopsy to be done on your body after a natural death?	Yes, if it is legally required	84	50.3
	No, it mutilates the body	15	9.0
	No, it is of no use	19	11.4
	Not sure, it depends on family	49	29.3
Sexual intercourse with a consenting adult woman is	Criminal offense	38	22.8
	Civil offense	31	18.6
	No offense	84	50.3
	Cognizable offense	14	8.4
Making sexually colored remarks to women is	Sexual Harassment	106	63.5
	Statutory Rape	7	4.2
	Indecent Assault	31	18.6
	No crime	23	13.8
Statement recorded by Police is	Admissible in court	75	44.9
	Not admissible in court	29	17.4
	Cannot be challenged	13	7.8
	Accepted in court	50	29.9
After two living girls to the Parents, the sex determination of the third child should be	Optional to get wanted child	27	16.2
	Compulsory to avoid unwanted child	26	15.6
	Sex determination should not be permitted	104	62.3
	Should be no restrictions on sex determination	10	6.0

101 (60.5%) knew about the correct quantum of punishment that could be given for medical negligence[5] as shown in table 1.

Awareness about Assisted Reproductive technology provision among the population was inadequate 133 (79.6%) of participants did not know the correct answer. 34 (20.4%) participants responded rightly as it depends on the age of the wife.[6]

120 (73%) respondents felt harassment by Police or delay in settling cases as the main reason for people avoiding legal remedies as shown in table 3.

Most of the participants 104 (62.3%) wanted to seek second medical advice from a specialist which can be due to conflict of interest and rampant malpractices among private physicians.

The majority of the study participants 119 (71.3%) do not blame the doctors and staff of the clinic, and 48 (28.7%) correctly feel the responsibility of doctors and staff for keeping the mentally ill person restrained.[7]

62 (37.1%) study participants correctly knew about the valid ground for divorce as per provisions of the Hindu marriage act, however substantial number, that is 51(30.5%) gave sterility as a valid reason and 45 (26.9%) wrongly think that second marriage is a valid ground for divorce.[8]

A total of 111 (66.5%) study participants correctly knew that

Table 5 : The attitude of participants regarding ethical & legal issues in MLC (n=167).

Question	Response	Frequency (n)	Percentage (%)
You have witnessed a serious road traffic accident, what will you do first?	Run away from the site of the accident	11	6.6
	Inform Police	33	19.8
	Provide emergency first aid and report to Police	117	70.1
	Catch the culprit	6	3.6
The dead body is brought to casualty, on examination you find him dead, what will be your response?	Do the complete examination of the body and initiate an injury report	55	32.9
	Inform Police	74	44.3
	Issue death certificate	18	10.8
	Hand over the body to relatives	20	12.0
If your son commits the crime of murder, what will be your reaction?	Will keep quiet	12	7.2
	Try to forget it	3	1.8
	Inform Police	129	77.2
	Inform the family of the dead person	23	13.8
If a case of poisoning is reported to your clinic, what will be your response?	Ask the patient to go to the Government hospital	22	13.2
	Give first aid and refer to a higher Centre	23	13.8
	Stabilize patient, initiate MLC, inform Police & refer if required	120	71.9
	Inform Police	2	1.2
If your close relative is mentally ill, what will be your reaction?	Conceal his/her condition from society	20	12.0
	Admit to Psychiatric hospital	137	82.0
	Consult a Tantrik	7	4.2
	Turn him out of the house	3	1.8

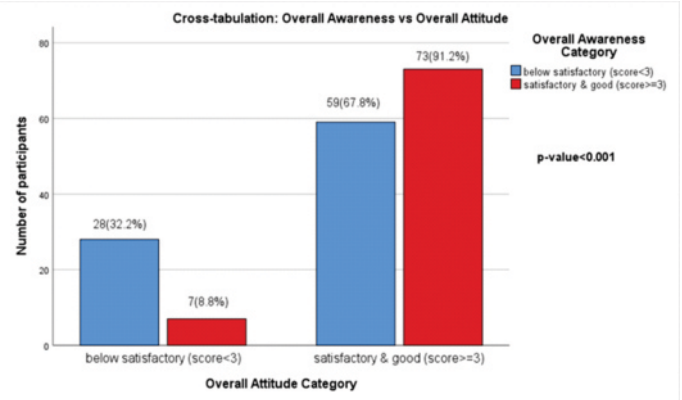

Figure 1 : Association between Overall awareness and Overall attitude among study participants (n=167)

patients shall be urgently examined to preserve evidence and give protective treatment Sec. 92 IPC.[9]

84 (50.3%) of the participants felt an autopsy to be performed on their body after natural death only if it was legally required, which

was not legally needed 49 (29.3%) participants know that the family can permit an autopsy in a case of natural death as shown in table 4.

84 (50.3%) of the participants felt sexual intercourse with consenting adult women is no offense, 38 (22.8%) of the participants feel it was a criminal offense. [10]

The majority is 106 (63.7%) of the participants correctly perceived sexually colored remarks to women as sexual harassment, and 31 (18.6%) of the participants felt it was an indecent assault.[11]

125 (74.8%) participants wrongly perceived that statement taken by police was admissible or accepted in the court, and only 29 (17.4%) correctly knew that it was not admittable in court.[12]

104 (62.3%) participants responded that sex determination should not be permitted. Perceptions of the majority of respondents were in agreement with the provisions of the Pre-conception and Pre-natal diagnostic techniques act, 1994 that sex determination should not be permitted.[13]

When asked about their response as a witness to a road traffic accident, 70.1% of participants said they would provide emergency first aid and report to police and refer if required as shown in table 5.

74 (44.3%) participants believed that the police should be informed immediately when a brought dead case is received. Similar findings were reported in another study done by Magda et al which showed that 57.3% of the study participants knew in case of death in an MLC, the dead body cannot be handed over to relatives.[14]

After the knowledge of murder - 77.2% of participants responded as will inform Police which is the correct approach.[15]

A good number, 71.9% know that when a poisoning case was brought to the clinic doctor has to stabilize the patient, initiate MLC, inform the police and refer if required.[16]

If a close relative is mentally ill-82.0% of respondents want to admit to a psychiatric hospital which is the correct attitude and 12% want to conceal his/her condition from society which is ethically worng.[17]

Figure1. Association between overall awareness and overall attitude among study participants (n=167)

The result showed that 7 (8.8%) participants with satisfactory awareness regarding medico-legal issues were having below satisfactory attitudes. 59 (67.8%) participants were having good attitudes but below satisfactory awareness.

This association between awareness and attitude of participants was statistically significant ($p<0.001$) as shown in Figure 1. It may be possible due to the usual awareness–attitude gap.

Conclusion :

This study showed that the majority of participants had poor overall awareness of ethical and legal issues and those who were having better overall awareness were not having a satisfactory attitude. The overall perception of the participants, because of conflict of interest is as expected. It needs to be improved through interactions between clinicians and clientele.

The study found a significant difference between the awareness and attitude of participants regarding medico-legal issues. This difference could be minimized by conducting awareness and attitude modulation programs among various groups at regular intervals.

Limitation of the study:

1.Limited sample size.

2. Study was confined to a single tertiary hospital, so its findings cannot be generalized.

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Conflict of interest: The Authors declare that there is no conflict of interest.

Ethical Approval: Prior clearance and Approval was taken.

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ORIGINAL ARTICLE

The Difference of Mandibular Dimensions Using Cone Beam Computed Tomography for Sex Determination in Forensic Odontology: A Systematic Literature Review

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Abstract :

Mandibular assessment using cone beam computed tomography (CBCT) can accurately provide the measurements for reconstructing and imaging of craniofacial structures in sex determination. The aim of this study was to determine the difference of mandibular dimensions between male and female and the greater mandibular measurement for sex determination using CBCT. Searching literatures was assisted by, into consideration four journal databases including PubMed, EBSCO, Pro Quest, and Google Scholar until March 3, 2021 with PRISMA method and relevant keywords. Review of literature quality was done by Newcastle-Ottawa Quality Assessment Scale (NOS). Inclusion criteria were population (male and female mandibles), intervention (CBCT), and outcome (differences of mandibular measures in males and females). Eight literatures were used in the study to analyze the difference of mandibular dimension with total sample of 1252 mandibles. Mean of mandibular dimensions through bigonial breadth, bicondylar breadth, ramus length, mandibular length, minimum ramus breadth, and gonial to gnathion length were significantly higher in males than females. Mean of gonial angle measure was significantly higher in female than male according to Tassoker et al, Abofakher et al, and El-Fotouh et al. Conversely, Gamba et al. showed the mean value of gonial angle was significantly higher in males than females. The most accurate mandibular measurement sorted from seven literature studies were bigonial breadth, ramus length, gonial angle, bicondylar breadth, mandibular length, minimum ramus breadth, and gonial to gnathion length. It suggests that according to seven varied studies the most accurate mandibular dimensions showed in different values as a result of diverse population of each study

Keywords : Mandibular Dimensions; Cone Beam Computed Tomography; Sex Determination.

Introduction :

Human teeth and skull bones are hard and dense tissues, which resist destruction under high temperatures.[1-4] Mandible is one of the most durable facial bones that maintains the bone shape better than the other facial bones for sex determination.[3-6] CBCT can precisely measure an object at certain distance, promising the feasible way for mandibular measurement in sex determination.[6-9] The radiographic images may eliminate distortion and superimposition.[8-10]

Objective of the current study was based on PICO (population, intervention, comparison, outcome) method. Population were male and female mandibles. Intervention was CBCT and no comparison was used in this study. The outcome was the differences in male and female mandibular measure and the most accurate mandibular measurement for sex determination. Therefore, this study was aimed to identify the difference of mandibular dimension using CBCT in determining sex and to find out the most accurate measurement for sex determination.

Methodology :

Search Strategy :

A systematic review is a study that collects all evidence from research observations that fit pre-defined inclusion criteria to answer specific research questions. The study was approved by institutional ethics and research committee. The literature search was carried out using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) methods.[11] This research was performed during the period between January 2021 - April 2021. The data were collected by searching on online literature using PICO selection criteria.

Online literature searches were sourced from four journal databases, namely Pubmed, EBSCO, Pro Quest and Google Scholar. Selected keywords according to MeSH (Medical Subject Headings) advanced search facility or Boolean operators were "mandibular measurement" and "cone beam computed tomography" and "sex determination".

Inclusion Criteria :

The inclusion criteria of the study were according to the PICO format previously mentioned.

Exclusion Criteria :

The exclusion criteria in this study include: literatures that are not in English, articles that published earlier than the year of 2011, and literature that cannot be downloaded in full text.

Data Items :

The data collection method in this study was searching journals that was relevant or related to differences of mandibular measure between male and female through CBCT

Method for Review of Literature Quality :

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Review of literature quality was done by NOS criteria for a cross-sectional study design. The quality of the study was evaluated by all authors. Sampling, examination methods, comparisons, and results were assessed against these NOS criteria. A good score requires 3-4 stars in selection, 1-2 stars in comparison, and 2-3 stars in results. A fair score requires 2 stars in the selection, 1-2 stars in comparison, and 2-3 stars in the results. A poor score is only 0-1 stars in the selection, 0 stars in the comparison, or 0-1 stars in the result. To be able to be reviewed, the journal must at least have a fair score.[12]

Results :

The results of literature searches carried out until March 3, 2021 from four database journal such as Pub Med, EBSCO, Pro Quest, and Google Scholar obtained 226 literatures. The literature consists of 12, 3, 163, 48 studies on Pub Med, EBSCO, Pro Quest, and Google Scholar, respectively. The 33 duplicate studies were excluded using Mendeley so that only 193 literatures were carried out in screening. Result showed 185 literatures were eliminated due to irrelevancy of the content to inclusion criteria as well as unavailability of full access articles. Total of 8 literatures were examined for eligibility, no literature was excluded because it had a good quality journal according to the NOS criteria and could be analyzed to present a qualitative synthesis data study. The literature search diagram in this systematic review used PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method (Figure 1). According to the NOS category with a cross sectional study design, all the 8 literatures have met the required criteria to be reviewed (Table 1).

Table 2 exhibits characteristic of the sorted literatures showing the variety of study population, as well as the period of age. The results of the literature study consisting of mandibular measure, distance from the mental foramen to the mandibular foramen, and foramen magnum using CBCT are demonstrated in table 3. The research was conducted based on literature studies using CBCT radiographs through the non-pathological mandible in male and female patients. Mandibular measurement used in this systematic literature review is through bigonial breadth, bicondylar breadth, ramus length, mandibular length, gonial angle, minimum ramus breadth, and gonial to gnathion length.[6-8,10,13-16]

Table 3 shows mandibular measure, distance from mental foramen to mandibular foramen, and foramen magnum using CBCT consisting of:[6-8,10,13-16]

1. Mandible :

Mandibular measurement CBCT was carried out in reconstructive views, namely axial, coronal, and sagittal views. Mandibular size in eight literature studies consisted of :

Table 1 : Results for review of literature quality objectively using NOS with a cross sectional study design.[12]

No.	Author, Year	Selection	Comparability	Outcome	Category
1.	Dakhli et al, 2020.[6]	4	1	3	Good
2.	Tassoker et al, 2019.[8]	3	1	3	Good
3.	İlgüy D et al, 2014.[7]	4	1	3	Good
4.	Abofakher et al, 2020.[14]	4	1	3	Good
5.	Deng et al, 2016.[15]	4	1	3	Good
6.	Amin, 2018.[13]	4	1	3	Good
7.	El-fotouh et al, 2018.[16]	4	1	3	Good
8.	Gamba et al, 2016.[10]	4	1	3	Good

Table 2 : Characteristics of study literature.

No	Author	Year	Research Title	Population	Sample		Age (years)
					M	F	
1.	Dakhli et al.[6]	2020	Sexual differentiation based on mandibular parameters. Utilizing cone beam computed tomography of a sample of Egyptian population.	Egypt	52	50	20 - 70
2.	Tassoker et al.[8]	2019	Comparison of cone beam computed to mography and panoramic radiography for mandibular morphometry.	Turkey	50	71	10 - 69
3.	İlgüy D et al.[7]	2014	Measurement of the foramen magnum and mandible in relation to sex using CBCT.	European descent	66	95	18 - 85
4.	Abofakh-eret al.[14]	2020	Mandibular sexual dimorphism analysis in CBCT scans in a Syrian sample.	Syrian	43	56	18 - 25
5.	Deng M et al.[15]	2016	Sexual determination of the mandible breadth in a central Chinese population sample: a three dimensional analysis.	Central Chinese	111	108	L: 20-67 P: 23-63
6.	Amin.[13]	2018	Osteometric assessment of various mandibular morphological traits for sexual dimorphism in Jordanians by discriminant function analysis.	Jordan	147	123	27 - 55
7.	El-fotouh et al.[16]	2018	Sex determination of the Egyptian population using mandibular CBCT scans: retrospective study.	Egypt	60	60	20 - 60
8.	Gamba et al.[10]	2016	Mandibular sexual dimorphism analysis in CBCT scans.	Brazil	74	86	18 - 60

Male (M), Female (F)

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Table 3 : Mandibular measure and distance from the mental foramen to the mandibular foramen, using CBCT in male and female patients.

Measure using CBCT	Author, Year							
	Dakhli et al, 2020.	Tasso-ker et al, 2019.	İlgüy D et al, 2014.	Abofakher et al, 2020.	Deng et al, 2016.	Amin, 2018.	Elfo-touh et al, 2018.	Gamba et al, 2016.
Mandible								
BGB	✓	✓	✓	✓	✓	✓	✓	✓
BCB	✓	-	✓	-	✓	✓	✓	✓
RH/RL	✓	✓	✓	-	-	✓	✓	✓
ML	✓	-	-	-	-	✓	-	-
GA	-	✓	✓	✓	-	✓	✓	✓
MRBr/ Rmin	✓	✓	✓	✓	-	-	-	✓
GGL	-	-	✓	-	-	-	✓	✓
Rmax	-	✓	-	-	-	-	-	-
RA	✓	-	-	-	-	-	-	-
CH	-	-	-	-	-	✓	-	-
Co - Go	-	-	-	✓	-	-	-	-
BA	-	-	-	-	✓	-	-	-
BM	-	-	-	-	✓	-	-	-
RCG	-	-	-	-	✓	-	-	-
RCA	-	-	-	-	✓	-	-	-
RCM	-	-	-	-	✓	-	-	-
RGA	-	-	-	-	✓	-	-	-
RGM	-	-	-	-	✓	-	-	-
RAM	-	-	-	-	✓	-	-	-
BH	-	-	-	-	-	-	✓	-
C anine BH First Molar	-	-	-	-	-	-	✓	-
Cn -Cr	-	-	-	-	-	-	✓	-
Distance from the Mental Foramen to the Mandibular Foramen.								
MF - IB	-	-	-	-	-	✓	-	-
MF - AC	-	-	-	-	-	✓	-	-
MF - SM	-	-	-	-	-	✓	-	-
MF - PBR	-	-	-	-	-	✓	-	-
MndF - PBR	-	-	-	-	-	✓	-	-
MndF - ABR	-	-	-	-	-	✓	-	-
MndF- Inf MN	-	-	-	-	-	✓	-	-
MndF -IB	-	-	-	-	-	✓	-	-

Table 4 : Difference in mean and standard deviation of male and female mandibular measure.[6,8,10,13-16]

Author, Year, Population	Mandibular Measure	Mean ± SD Mandibular Measure		P- value	Statistic Analysis
		M	F		
Dakhli I et al, 2020, Egypt.[6]	BGB BCB RH ML MRBr	86,6 ± 5,0 114,8 ± 7,4 56,0 ± 5,6 83,4 ± 7,2 24,7 ± 2,6	82.5 ± 4,4 106,7 ± 5,6 51,8 ± 4,1 74,8 ± 8,1 23,1 ± 3,2	<0,001* <0,001* <0,001* <0,001* 0,005*	Independent t-test
Tassoker et al, 2019, Turkey.[8]	BGB Right RH Left RH RightGA LeftGA Right MRBr Left MRBr	17,42 ± 0,98 6,51 ± 0,74 6,35 ± 0,70 117,13 ± 7,38 118,02 ± 7,88 2,89 ± 0,31 2,87 ± 0,34	16,38 ± 0,86 5,92 ± 0,47 5,83 ± 0,50 120,03 ± 6,06 119,41 ± 5,84 2,70 ± 0,26 2,65 ± 0,26	0,000* 0,000* 0,000* 0,024* 0,291 0,001* 0,000*	Independent t-test
İlgüy..D et al, 2014, European descent.[7]	BGB BCB RH GA MRBr GGL	100,33 ± 4,99 120,79 ± 5,68 61,67 ± 5,47 121,14 ± 6,56 29,89 ± 3,20 71,86 ± 4,33	94,77 ± 5,90 116,23 ± 5,50 54,72 ± 4,86 122,31 ± 6,79 28,09 ± 2,83 67,73 ± 5,69	0,001* 0,001* 0,001* 0,278 0,001* 0,001*	Independent t-test
Abofakher et al, 2020, Syrian.[14]	BGB GA MRBr	95,17 ± 6,45 127,11 ± 7,87 29,63 ± 2,90	86,84 ± 4,81 131,52 ± 6,08 27,89 ± 2,73	<0,001* 0,002* 0,003*	Independent t-test
Deng M et al, 2016, Central Chinese.[15]	BGB BCB	129,70 ± 5,02 100,19 ± 5,85	121,80 ± 4,56 93,55 ± 4,98	0,000* 0,000*	Independent t-test
Amin, 20180, Jordanian.[13]	BGB BCB RH ML GA	98,69 ± 5,82 121,84 ± 5,40 67,68 ± 6,39 95,77 ± 6,48 118,28 ± 22,23	92,16 ± 4,47 116,58 ± 10,96 62,71 ± 4,85 90,00 ± 3,88 147,06 ± 6,34	0,000* 0,000* 0,000* 0,000* 0,000*	Multivariate ANOVA
El-fotouh et al, 2018, Egypt.[16]	BGB BCB RH GA GGL	95,930 119,550 59,033 119,158 81,700	87,652 112,820 51,470 122,023 80,727	0,000* 0,000* 0,000* 0,008* 0,305	One way ANOVA test
Gamba et al, 2016, Brazil.[10]	BGB BCB RH GA MRBr GGL	118,48 ± 5,99 94,96 ± 6,08 54,36 ± 4,73 121,28 ± 8,21 28,70 ± 3,44 70,37 ± 4,65	110,03 ± 4,65 87,47 ± 5,36 49,41 ± 3,84 119,83 ± 6,68 28,91 ± 2,69 67,14 ± 3,93	< 0,01** < 0,01** < 0,01** 0,0140** 0,3414 < 0,01**	One way ANOVA test

Male (M), Female (F)

a. Bigonial breadth (BGB) is the distance between two gonions, included right and left gonial. CBCT measurements can be carried out in an axial view and gonial area is a dense radiopaque.

b. Bicondylar breadth (BCB) is the distance between the most lateral points of the two condyles. It can be interpreted in a coronal view and both condyles are shown as radiopaque areas.

c. Ramus length (RH) is the direct distance from the highest point on the condyles of the mandible to gonion. Measurements can be made in a sagittal view and a radiopaque area is visible on the CBCT.

d. Mandibular length (ML) is the distance between the tangent

Table 5..The most accurate mandibular measurement for sex determination using CBCT.[6,8,10,13-16]

Author, Year	Mandibular Measurement	P-value	Accuration	Statistic Analysis and Results
Dakhli et al, 2020.[6]	BCB RH ML BGB MRBr	<0,001* <0,001* <0,001* - -	-	Wilks lambda and discriminant function analysis. Bicondylar breadth, ramus length, and mandibular length showed the most significant results for sex determination. Mean value of the discriminant scores (centroid group) in the entire sample was 0.742 for male and -0.772 for female.
Tassoker M et al, 2019.[8]	-	-	-	-
İlgüy D et al, 2014.[7]	BGB RH GA GGL BCB MRBr	< 0,01* < 0,01* < 0,01* < 0,01* - -	Accuration for BGB,..RH, GA, GGL and foramen magnum 83,2 %	W*ilks lambda* and discriminant function analysis. Gonial angle, ramus length, gonial to gnathion length, and bigonial breadth showed the most significant results for sex determination.
Abofak -heret al, 2020.[14]	BGB GA MRBr Co-Go	- - - -	Accuration for MRBr, GA, Co-Go, and BGB 79,6 %	Discriminant function analysis. Minimum ramus breadth, Gonial angle, Coronoid to gonial length, and bigonial breadth showed the most significant results for sex determination. Discriminant score obtained from this equation is a score <0 (female) and a score> 0 (male). The mean score of discriminant (centroid group) in this study was 0.864 for male and -0.715 for female.
Deng Met al, 2016.[15]	BCB BGB	< 0,05* < 0,05*	78,4 % M, 76,9 % F 73,9 % M, 69,4 % F	W*ilks lambda* and discriminant function analysis univariat. The accuracy of the bicondylar breadth measurement was 77.6% and then the bigonial breadth was 71.7%. The bicondylar breadth was the most appropriate measurement of the mandible for sex identification.
Amin et al, 2018.[13]	BGB BCB RH ML GA Right CH Left CH MF-PBR MndF-IB	0,000* 0,000* 0,000* 0,000* 0,000* 0,049* 0,000* 0,000* 0,000*	81,2 % 73,5 % 71,3 % 75,7 % 81,8 % 59,1 % 75,7 % 70,2 % 73,8 %	W*ilks lambda* and discriminant function analysis Gonial angle with an accuracy of 81.8% was the most appropriate measure for sex identification. Bigonial breadth with an accuracy of 81.2% was used for sex identification through wilks lambda. Other measurements of the mandible that are most appropriate for gender identification were right and left coronoid height, distance between mental foramen and the posterior margin of the ramus and vertical distance between the mandibular foramen and the inferior margin of the ramus. The mean score of discriminant (centroid group) in this study was 1.12 for male and -0.989 for female. Discriminant score> 0.067 for male and <0.067 for female.
El-Fotouh et al, 2018.[16]	BGB BCB RH GA GGL BH canine BH 1st molar Cn-Cr	- - - - - - - -	Accuration for RL, BH Canine, Cn-Cr, and BGB 85,8 %	Discriminant function analysis Ramus length, distance from the inferior border of the mandible to the cervical canine, condyle to coronoid length, and bigonial breadth were the most precise measurements for gender identification. Score discriminant : positive score being male, negative score being female.
Gamba et al, 2016.[10]	BGB BCB RH GA GGL	- - - - -	Accuration for RL, GA, BGB, and BCB 95,1 %	Logistic regression. Bigonial breadth, bicondylar breadth, ramus length, and gonial angle showed the most accurate results for gender identification. A negative logit indicated a male mandible and a positive logit indicated a female mandible.

✓*Significant p<0,05 dan p 0,05, ✓Male (M), Female (F)

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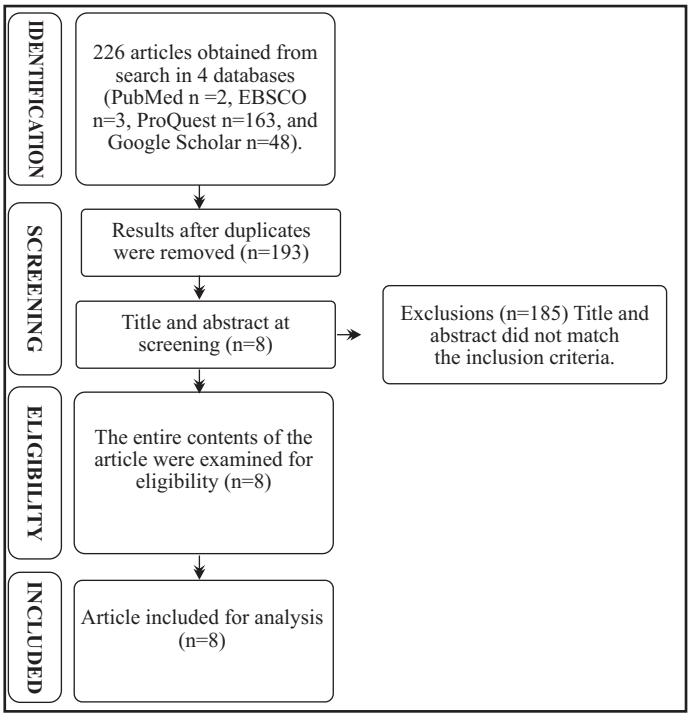

Figure 1: Literature search results using PRISMA methods (Preferred Reporting Items for Systematic Reviews and Meta-Analyse)

to the anterior margin of the chin and the tangent to the margin of the posterior ramus, which shows the radiopaque area on the CBCT. The measurement can be carried out in a sagittal view.

e. Gonial angle (GA) is the angle that forms between the inferior border of the mandible and the posterior edge of the ramus of the mandible. Measurements can be made in a sagittal view and the radiopaque area is visible on the CBCT.

f. Minimum ramus breadth (MRBr) is the smallest width of the mandibular ramus. Measurements can be made in the sagittal view and on the CBCT is radiopaque.

g. Gonial to gnathion length (GGL) is the distance between gonion and gnathion. Measurements can be made in the sagittal view and the radiopaque area is visible on the CBCT.

h. Rmax (maximum ramus breadth).

i. RA (ramus angle).

j. CH (coronoid height).

k. Co-Go (coronoid to gonion length).

l. BA (biantegonial notch breadth).

m. BM (bimental foramen breadth).

n. RCG (the ratio of bicondylar breadth to bigonial breadth).

o. RCA (the ratio of bicondylar breadth to bi-antegonial notch breadth).

p. RCM (the ratio of bicondylar breadth to bimental foramen breadth).

q. RGA (the ratio of bigonial breadth to biantegonial notch breadth).

r. RGM (the ratio of bigonial breadth to bimental foramen breadth).

s. BH canine (the distance from the inferior border of mandible to the neck of canine forms).

t. BH 1st molar (from lower border of mandible to the top of inter-septal bone).

u. Cn-Cr (length condyles to coronoid).

2. Distance from the mental foramen to the mandibular foramen in one literature consisted of:

a. MF-IB (Distance between the center of the mental foramen perpendicular to a tangent along the lower margin of the body of the mandible).

b. MF-AC (distance between the center of mental foramen and the superior limit of alveolar crest).

c. MF-SM (distance from the center of the mental foramen and the symphasis mentalis).

d. MF-PBR (distance from the center of the mental foramen to the posterior margin of mandibular ramus).

e. MndF-PBR (distance between the deepest point of the posterior border of the ramus to the center of the mandibular foramen).

f. MndF-ABR (distance between the deepest point of the anterior border of the ramus to the center of the mandibular foramen).

g. MndF-Inf MN (vertical distance between the deepest point on the mandibular notch to the center of the mandibular foramen).

h. MndF-IB (vertical distance between the center of the mandibular foramen to the inferior margin of the mandibular ramus).

Discussion :

Mandible is the skull bone that plays an important role in sex determination because it is one of the largest and strongest skull bones. Mandibular measurements were performed using CBCT radiographs with multiple reconstructive views of the male and female patients.[4,6-8,17-19] After that, mandibular measurements can be performed using CBCT software.[6-8,10,13-16]

Difference in mean and standard deviation of male and female mandibular measure

The results in table 4 show the mean difference in mandibular size in male and female patients. This study was conducted on populations of Egypt, Brazil, Jordan, Turkey, European descent, Syria, and China.[6-8,10,13-16] Mean of mandibular measure through bigonial breadth, bicondylar breadth, ramus length, mandibular length, minimum ramus breadth, and gonial to gnathion length were significantly higher in males than females ($p < 0.05$).[6-8,10,13-16] Mean of gonial angle measure is significantly higher in females than males ($p < 0.05$) according to Tassoker et al., Abofakher et

al., and El-Fotouh et al., However Gamba et al. Showed that mean of gonial angle measure was significantly higher in males than females ($p < 0.01$). [8,10,14,16]

The masticatory forces in males is higher than females so that it affects the mandibular measure. The growth process in the adult phase shows a greater growth rate and speed in males than females.[8,13,18,20-22] Sex hormones such as testosterone, estrogen and progesterone affect the growth rate and stage of development of the mandible. Male mandibles tend to be bigger and thicker and are affected by the high testosterone hormone. Female reach puberty earlier than male are influenced by the hormones estrogen and progesterone.[8,13,23] The contraction of the masticatory muscles exerts a more biomechanical effect on mandibular growth in males. This causes the size of the mandible through bigonial breadth, bicondylar breadth, ramus length, mandibular length, minimum ramus breadth, gonial to gnathion length greater in males than females. This was caused by variations in size and shape of the mandible between a number of samples used with variety of populations and different races.[8,13,18,20-22] Mean of the gonial angle in males tends to be lesser than females.There is a relationship between cortical bone thickness and the size of the gonial angle.[8,14,16,24,25] The gonial angle gets smaller and cortical bone gets thicker. The masseter and medial pterygoid muscles attach to the gonial angle area can affect the shape of the mandibular body. The stronger the pull of these muscles, gonial angle gets smaller. Males tend to have stronger masticatory muscle strength, so that gonial angle is smaller than female.[8,24] Gamba et al. found that gonial angle is higher in male than female in Brazil. The distinct results of mean gonial angle are due to differences in each race influenced by the habit of chewing and the food consumed.[10] However, mean of left gonial angle (Tassokeret al.), gonial angle (İlgüy D et al.), gonial to gnathion length (El-Fotouh et al.) and minimum ramus breadth (Gamba et al.) showed no significant differences in male and female.[7,8,10,16]

The most accurate mandibular measurement for sex determination using CBCT

Mandibular measurements used for sex determination is influenced by different populations. This study was conducted on populations of Egypt, European descent, Syria, central China, Jordan, and Brazil.[6-7,10,13-16] Table 5 denotes the most precise measurement of the mandible using CBCT radiographs for sex determination. Dakhli et al found that bicondylar breadth, ramus length, and mandibular length showed the most significant results for sex determination in Egypt.[6] İlgüy D et al found that gonial angle, ramus length, gonial to gnathion length, and bigonial breadth in Europian descent.[7] Abofakher et al. showed that the most appropriate sex identification through minimum ramus breadth, gonial angle, coronoid to gonial length, and bigonial breadth in Syria.[14] Deng et al. found the accuracy of bicondylar breadth measurement is 77.6% and the bigonial breadth is 71.7% for sex determination in Central China.[15] Amin found that gonial angle, bigonial breadth, right and left coronoid height, distance between mental foramen and the posterior margin of the ramus and vertical distance between the mandibular foramen and the inferior margin of the ramus give the most significant results for sex determination in Jordan. The most accurate for sex determination is gonial angle (81,8 %).[13] El-Fotouh et al. showed that using ramus length, distance from the inferior border of the mandible to the cervical canine, condyle to coronoid length, and bigonial breadth were the most precise measurements for sex identification in Egypt. Accuracy for sex identification through 4 mandibular measurements are 85, 8%.[16] Gamba et al found that bigonial breadth, bicondylar breadth, ramus length, and gonial angle give the most accurate results for sex identification in Brazil. Accuracy for sex identification on these 4 mandibular measurements are 95.1%.[10]

Several previous studies from various countries have investigated sexual dimorphism through mandibular measurements which are almost the same as this study but there are differences in measurement accuracy.[4,26] Saini et al. evaluated that five variables measured on the preserved mandibular ramus indicated that ramus length was the most precise measurement in the Indian population to determine sex. The over all accuracy of those five variables was 80.2%, which showed more accurate results in female than male.[26] However, Vinay et al. showed the most significant mandibular measurement for gender identification was bigonial breadth, bicondylar breadth, and mandibular length on a population in South India.[4] Sex determination through CBCT in several studies has different results in each population.[27,28] Several factors must be considered before determining the significance of the mandibular size that can be used for sex determination.[6-7,10,13-16] Differences in musculoskeletal development and growth rates in males and females influence sex identification.[29-30] Geographical and social environmental factors, such as: nutrition, weather, disease, occupation, or habits affect the development of the mandible. Mean of mandibular dimensions originating from one particular population cannot be attributed to another one because the magnitude of the sex-related differences varies widely between these populations. These differences are influenced by race and ethnicity, the number of samples used, methodology for sex determination which should be validated for different population groups.[10,13,27,29]

Conclusion :

Mean of mandibular dimensions using bigonial breadth, bicondylar breadth, ramus length, mandibular length, minimum ramus breadth, and gonial to gnathion length were higher in males than females except gonial angle is higher in females than males. Mandibular dimension which most accurately predict sex showed different results from all eight literatures due to population differences used in this study.

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ORIGINAL ARTICLE

A Record Based Study of Death due to Road Traffic Accident brought for Postmortem Examination at Tertiary Care Center Bhavnagar

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Abstract :

Road traffic accidents happen to be a leading cause of death among young people and cause considerable economic losses to victims and their families and the nation at large. This is a retrospective autopsy-based study consisting of 120 medico-legal autopsies performed at the mortuary complex of the tertiary care center Bhavnagar during the period from 1st September 2019 to 31st August 2020. Out of the 914 medico-legal autopsies performed during the study period, 120 (13.12%) were due to fatal RTA. There were 103 (85.83%) males and 17 (14.17%) females. 11 to 20 years age group showed the highest number of victims of 24 (20%). The maximum of road traffic deaths of 18 (15%) was shown in March 2020 and a minimum of 2 (1.66%) in April 2020. The highest number of injuries were head injuries of 92 (76.66%), followed by thoracic injury of 30 (25%) and abdominal injury of 21 (17.5%). Road traffic accidents are increasing at an alarming rate in rural and urban areas. Most of them are caused by human errors and they can be prevented by providing road safety education to all. In conclusion, most of the victims of road traffic accidents were young males and the productive age group.

Keywords : Autopsy; Road Traffic Accident; Injury; Fracture.

Introduction :

Road Traffic accidents can be defined as any vehicular accident occurring on the roadway, originating on, terminating on, or involving a vehicle partially on the road way.[1] Road traffic injuries are the leading causes of death in the world.[2] This includes collision of an automobile with a pedestrian/vehicle rider/pillion rider/driver/passenger/or another automobile or with a non-automobile on the roadway or falls from a moving vehicle causing injuries or death of the individuals is involved. The rapid urbanization and industrialization have resulted in a revolutionary increase in the number of motor vehicles globally which have led to an increase in morbidity and mortality due to road traffic accidents especially in developing countries like India. The causative factors may be human or/and environmental. The important factors are human errors like driver fatigue, poor traffic sense, speeding and overtaking, violation of traffic rules, mechanical fault of the vehicle, poor road conditions, traffic congestion, road encroachment, etc. out of which most of them are preventable.

Whatever the cause may be, once the accident occurs and a person falls from the vehicle, it results in either morbidity or mortality. Road traffic accidents happen to be a leading cause of death among young people and cause considerable economic losses to victims and their families and the nation at large.

The first death due to a motor vehicle was registered in 1896 in the United Kingdom.[3] RTAs are considered the third deadly killer, next to heart disease, and cancer.[4] Accidents represent a major epidemic of non-communicable and fatal diseases in the present century. Therefore, the present study is the smallest attempt to understand the magnitude of the problem and aimed at analyzing the various factors related so that it helps in to formulate the preventive measures to reduce the burden caused by such accidents.

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Material and Methods :

The present cross-sectional study was conducted at the mortuary complex of tertiary care center Bhavnagar. Ethical clearance was obtained from ethical committee before starting the study. This study includes all fatal cases of Road traffic accidents brought for medicolegal postmortem examination to the mortuary of tertiary care center Bhavnagar during the period from 1st September 2019 to 31st August 2020. From that period 120 autopsy cases of fatal road traffic accidents were selected for the present study.

There was a detailed proforma prepared to capture data from the record section of Sir T Hospital, Bhavnagar, and the observations were thereafter statistically analyzed.

Results :

Out of the 914 medico-legal autopsies performed during the study period, 120 (13.12%) were due to fatal RTA. There were 103 (85.83%) males and 17 (14.17%) females. 11 to 20 years age group showed the highest number of victims of 24 (20%). The maximum of road traffic deaths of 18 (15%) was shown in March 2020 and a minimum of 2 (1.66%) in April 2020. The highest number of injuries were head injuries of 92 (76.66%), followed by thoracic injury of 30 (25%) and abdominal injury of 21 (17.5%). Among these cases, 69 (57.50%) died in hospital despite medical interventions, 42 (35%) died on the way to the hospital and, 9 (7.5%) died on spot.

Discussion :

Males outnumbered the females in a total number of deaths due to RTA, 103 (85.83%) male cases compared to 17 (14.17%) female cases. [Chart no.1] Studies conducted by other authors also showed marked male preponderance in road accidents.[1,5-11]

11 to 20 years age group showed the highest number of victims of 24 (20%), followed by 21-30 years 22 (18.33%), 31-40 years 20 (16.66%), 51-60 years 20 (16.66%), 41-50 years 16 (13.33%), >60 years 12 (10%), and least in the age group of 0-10 years 6 (5%). [Table no.1] Similar finding of predominance of young and productive age group was reported by Kumar et al,[1] Das DK,[5]Anantharaman VV et al,[7] Singh SK et al,[8]Kakkar R et al,[7]

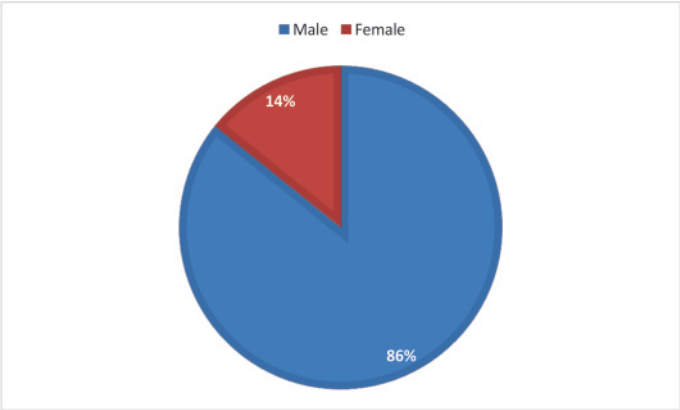

Chart 1: Sex Wise Distribution of RTA death Cases.

Table 1: Age-wise distribution of RTA death Cases.

Age	(n=120)	%
0 - 10	6	5%
11 - 20	24	20%
21 - 30	22	18.33%
31 - 40	20	16.66%
41 - 50	16	13.33%
51 - 60	20	16.66%
>60	12	10%

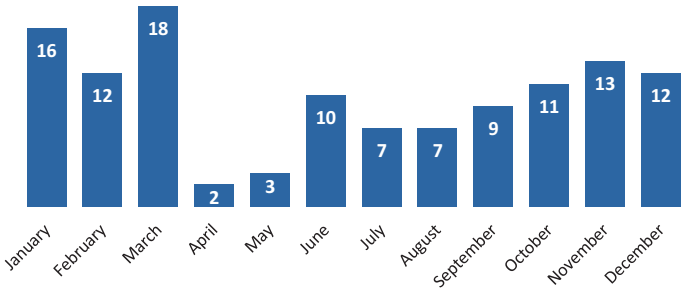

Chart 2 : month-wise distribution of RTA death cases.

Table 2 : RTA deaths according to the place of death.

Place of Death	(n=120)	%
Spot	9	7.50%
On the way to hospital	42	35%
Hospital	69	57.50%

Table 3 : RTA Death cases according to Length of hospitalization.

Length of Hospitalization	(n= 69)	%
<24 hours	32	46.37%
> = 24 hours to <1 week	27	39.13%
> = 1 week to <1 month	9	13.04%
> = 1 month	1	1.45%

Table 4: Distribution of head injuries in RTA death cases.

Head Injury	(n=92)	%
Scalp Injury	68	73.91
Crushed head injury	2	2.17
Skull Bone Fractures	70	76.08
Extradural Haemorrhage	35	38.04
Subdural Haemorrhage	68	73.91
Intracerebral Haemorrhage	4	4.34

Bhagwat DL et al,[10] Selvaraj T et al,[11] and Hadaye RS et al.[12]

The maximum of road traffic deaths of 18 (15%) was shown in March 2020 [Chart no.2], followed by January 16 (13.33%), November 13 (15.6%), February and December 12 (10%), October 11 (9.16%), June 10 (8.33%), September 9 (7.5%), July and August 7 (5.83%), May 3 (2.5%), and least in April 2 (1.66%). In contrast studies conducted by Das DK in Barpeta district and Singh SK et al in Jhansi maximum number of cases were recorded in the winter months (Dec to Feb) 33.52% and 37.24% respectively.[5,8]

In our study, most of the deaths took place in Hospital during treatment 69 (57.50%), 42 (35%) deaths happened on the way to the hospital, and 9 (7.50%) deaths happened on the spot. [Table no.2] In contrast studies conducted by Das DK in Barpeta district and Kalougivaki JJVP et al in Fiji maximum number of cases were died on the spot followed by enroute to hospital.[5,6]

Among the deaths happened in hospital (n=69), maximum deaths

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Table 5: Distribution of Thoracic injury in RTA death cases.

Thoracic Injury	(n=30)	%
Hemothorax	7	23.33
Ribcage Fractures	23	76.66
Lung Injury	13	43.33
Injury to major blood vessel Aorta	1	3.33

Table 6 : Distribution of Abdominal injury in RTA death cases.

Abdominal Injury	(n=21)	%
Hemoperitoneum	20	95.23
Mesenteric Injury	1	4.76
Liver injury	15	71.42
Spleen injury	8	38.09

happened within 24 hours of hospitalization 32 (46.37%), 27 (39.13%) cases survived >24 hours to <1 week, 9 (13.04%) cases survived >1 week to < 1 month, and only 1 (1.45%) case survived >1 month to <3 months. [Table no.3]

Among the RTA death cases, there were 92 (76.66%) cases of head injury. Scalp injury was 68 (73.91%), crushed head injury was 2 (2.17%), Skull Bone Fractures were 70 (76.08%), Extradural Haemorrhages were 35 (38.04%), Subdural Haemorrhages were 68 (73.91%), and Intracerebral Haemorrhages were 4 (4.34%). [Table no. 4] While study conducted by Selvaraj T et al were noted fractured skulls in 67%, Subdural Haemorrhage in 78%, Subarachnoid Haemorrhage in 62%, Extradural Haemorrhage in 49% and Intra-cranial injuries in 22%.[11]

Among the RTA death cases, there were 30 (25%) cases of Thoracic injury. Hemothorax was 7 (23.33%), Ribcage Fractures were 23 (76.66%), Lung injury was 13 (43.33%), and Injury to major blood vessel Aorta was 1 (3.33%). [Table no.5]

Among the RTA death cases, there were 21 (17.5%) cases of Abdominal injury. Hemoperitoneum was 20 (95.23%), Mesenteric injury was 1 (4.76%), Liver injury was 15 (71.42%), and Spleen injury was 8 (38.09). [Table no.6]

Similarly Highest number of head injuries, followed by thoracic injuries and abdominal injuries were recorded by Das DK,[5] Kalougivaki JJVP,[6] Anantharaman VV et al,[7] Bhagwat DL et al,[10] Selvaraj T et al,[11] and Hadaye RS et al.[12]

Data recovered from RTA death cases, some of the cases was having the head and thoracic injury, some of having thoracic and abdominal injury, some of having head and abdominal injury, and some of the cases having all injury. Because of these mixed injuries, the total sum of table no. 4, 5 & 6 is not equal to the total RTA death cases (120).

Conclusion :

Road traffic accidents are increasing at a very high rate, causing the loss of valuable workforce and resources. Most of them are caused by human errors and they can be prevented by providing road safety education to all. Improvement of roads, street lights, and displaying traffic signs needed.

Strict enforcement of laws regarding the driving of vehicles, wearing of helmets, applying seat belts is needed. As such, intracranial hemorrhage was the most common cause of death due to RTAs in our study.

It was observed that in the majority of cases, intracranial hemorrhage contributed either directly or indirectly to death. There is a need to stress the importance of the usage of helmets, seat belts, and adherence to traffic rules to reduce the incidence of road traffic accident.

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ORIGINAL ARTICLE

Magnitude of Medicolegal Issues among People Who Inject Drugs in New Delhi: A Cross-Sectional Study

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Abstract :

Besides posing a significant health burden, people who inject drugs (PWID) are also implicated in violence, acquisitive crimes, accidents, and suicides. This cross-sectional, observational study was conducted from November 2016 to March 2018 at a tertiary care centre of New Delhi.The data on medicolegal issues and their characteristics were collected through an interviewer-administered structured questionnaire from PWID receiving opioid substitution therapy (OST), and statistical analysis was performed using descriptive statistics and chi-square test. Out of 100 male PWID, nearly half of PWID (n=48, 48%) were involved in criminal activities. Among the population of PWID with criminal activities, acquisitive crimes were the most common (n=37, 37%) type of crime committed. About 29 (29%) PWID revealed suicidal ideations, 12 (12%) attempted suicides, and about one in five (n=21, 21%) PWID had nonsuicidal self-injuries (NSSI) in the preceding year. A statistically significant association was observed between the history of injecting drug use in the preceding three months with the criminal activities of the user ($\chi 2$=3.853; p=.050). Acquisitive crimes were significantly associated with homelessness ($\chi 2$=5.884; p=.015). The evidence from the present study suggests that acquisitive crimes, suicidal ideations, and self-harm are highly prevalent among PWID. Efforts should be focused on strict adherence to OST with effective psychiatric counselling, family therapy, and social assistance programs to mitigate PWID's medicolegal issues at large.

Keywords : People who inject drugs; Opioid substitution therapy; Medicolegal issues; Criminal activities; Suicide; Forensic Psychiatry.

Introduction :

According to World Drug Report 2020, nearly one in seven people who used illicit drugs in 2018 suffer from drug use disorders, of which opioids represent the significant burden on morbidity and mortality.[1] Estimates revealed that people who inject drugs (PWID) have a 15 times higher risk of dying from premature deaths than the general population.[2] Suicide, infectious diseases, accidental overdose, and trauma from violence or accidents are the most common causes of premature death among PWID.[3,4]

In addition to life-threatening health hazards, illicit drug use also has potential family, social, economic, legal, and political level implications.[5] A range of crimes from stealing, shoplifting, robbery to assault, murder, and rape by illicit drug users are usually committed either due to psychotic effects of drugs on the brain or due to the constant need for money to purchase drugs to sustain their habits. The latter is known as acquisitive crimes, more common among heroin (opioid) users than violent crimes.[6] Further, deliberate self-harm, nonsuicidal self-injuries (NSSI), breakdown in interpersonal relations, homelessness, and psychiatric com-orbidities are also increasingly reported among PWID.[7-9]

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Researches in India is often dedicated to socio-demographics, the pattern of drug use, and suicide among PWID.[10-16] However, little attention has been paid to the medicolegal issues among them. Given the dearth of literature, the present study was carried out to measure the prevalence of medicolegal issues and assess its determinants among PWID receiving opioid substitution therapy (OST). Such a study might be helpful for a better understanding of the problems among PWID and devise an effective intervention strategy to mitigate them.

Material and Methods :

This cross-sectional study was conducted at the Department of Forensic Medicine in collaboration with Department of Psychiatry and Drug Deaddiction Centre, Lady Hardinge Medical College & Associated Hospitals, New Delhi. The study period was between November 2016 and March 2018. On admission, each PWID was clinically evaluated by the psychiatrist, and buprenorphine maintenance therapy was instituted after the assessment. Convenience sampling method was employed to include all the eligible study participants because of the anticipated limited availability of study participants during the study period. In this study, PWID was considered the drug users who had a history of injecting heroin or any other form of opioid at least once in the preceding 12 months. All PWID aged over 18 years, currently receiving OST, and consented to participate in the study were included. PWID aged over 18 years but having a mental illness and not consented to participate in the study were excluded. Ethical clearance was obtained from Institutional Ethics Committee before the commencement of the study vide LHMC/ECHR/2016/55R1 dated 02/11/2016.

Participants were explained in detail regarding the purpose of this study and informed that their information would be confidential and professional secrecy would be maintained. Written informed consent was obtained from all the participants before starting the interview. Help of the family members, NGO members, and the staff of the OST centre was sought wherever necessary to clarify the participants. Self-reported information on socio-demographic factors, type, and frequency of the criminal activities, accidents, and suicidality associated with the PWID was collected through face-to-face interviews using researcher administered structured questionnaire.

Statistical Analysis:

The data was entered in MS EXCEL spread sheet, and analysis was done using statistical package for social sciences (SPSS) for windows version 25. Categorical variables were presented in number and percentage (%), and continuous variables were presented as mean ± SD and median. Data were tested for normality using the Shapiro Wilk test and further checked graphically for symmetry. The Chi-square test was used for comparison between non normal, categorical data. Statistical significance was fixed at 5% level ($P < 0.05$).

Results :

Out of 116 PWIDs approached, only 100 were found eligible as per the inclusion criteria and recruited in the present study. During the study period, no eligible female PWID was receiving OST. It was found that nearly half (n=48, 48%) PWID self-reported to have ever committed criminal activities because of their substance use, whereas 52 (52%) PWID declared no such criminal activities (Table 1). Among the population of PWID with criminal activities (n=48), the commonest type of crime committed reported was acquisitive crimes (n=37, 37%) in the form of stealing, pickpocketing, followed by drug-related offences (n=25, 25%), for instance, selling drugs. Violent crimes (n=11, 11%) such as assault and gang activities were the least common crime self-reported by PWID (Table 1). Nearly half of the crimes (n=23, 48%) were committed more than once a week frequency and closely followed by once a week (n=22, 46%) (Table 1) About a quarter (n=24, 24%) of PWID had a history of ever been in prison.

Table 1 : Medicolegal issues among people who inject drugs receiving opioid substitution therapy

Variable	n (%)
Criminal Activities	
Yes	48 (48%)
No	52 (52%)
Type of crimes*(n=48)	
Acquisitive crimes	37
Drug related offences	25
Violent offences	11
Frequency of committing crimes (n=48)	
Once a month	2 (4%)
Once a week	22 (46%)
More than once a week	23 (48%)
Daily	1 (2%)
Ever been to Prison	24 (24%)
Accident under the influence of drugs	45 (45%)
Suicidal ideations in the preceding year	29 (29%)
Suicidal attempts in the preceding year	12 (12%)
NSSI†in the preceding year	21 (21%)

Note.* Multiple responses received. †NSSI: Nonsuicidal Self Injuries.

Table 2 : Criminal activities among people who inject drugs.

Variables	Criminal Activities No	Yes	Chi square	p value
Age Group				
Young Adults (18-35y)	25	20	.677	.713
Middle-aged Adults (36-54y)	24	26		
Old adults (>55y)	3	2		
Marital Status				
Married	24	17	1.190	.275
Unmarried	28	31		
Family Type				
Nuclear	51	47	.003	.954
Joint	1	1		
Education				
Illiterate	17	18	.254	.615
Literate	35	30		
Employment Status				
Unemployed	14	10	.507	.476
Employed	38	38		
Socio economic status				
Poor	43	38	.202	.653
Middle	9	10		
Injecting practice in the preceding three months				
No	17	25	3.853	.050
Yes	35	23		
Alienation of subject from the family				
No	17	14	.145	.703
Yes	35	34		
Homelessness				
Yes	38	41	91	.130
No	1	47		

The next section of the study was concerned with the extent of crimes committed under the influence of drugs. Forty-four (44%) PWIDs were reported to have met with an accident under the influence of substances. (Table 1) In the preceding year, while 29 (29%) PWID had suicidal ideations (SI), remarkably 12 (12%) PWID among them had attempted suicide under the influence of substances. About one in five (n=21, 21%) PWID reported non-suicidal self-injuries (NSSI) in the preceding year (Table 1).

A statistically significant association was found between the history of injecting drug use in the preceding three months with the criminal activities of the user ($\chi2=3.853$; p=.050). (Table 2) Statistically, a significant difference was observed for NSSI among the different age groups ($\chi2=7.990$; p=.018), married ($\chi2=13.608$; p=.000), literate ($\chi2=14.314$; p=.000), middle class ($\chi2=14.147$; p=.000), and PWID who shared needle in the preceding three months ($\chi2=5.756$; p=.016) (Table 3) Suicidal ideations (SI) were significantly associated with PWID who had

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Table 3 : Nonsuicidal self-injuries (NSSI) among people who inject drugs.

Variables	Non-suicidal self-injuries No	Yes	Chi square	p value
Age Group				
Young Adults (18-35y)	40	5		
Middle-aged Adults (36-54y)	37	13	7.99	0.018
Old adults (>55y)	2	3		
Marital Status				
Married	25	16	13.608	.000
Unmarried	54	5		
Family Type				
Nuclear	77	21	.542	.461
Joint	2	0		
Education				
Illiterate	35	0	14.314	.000
Literate	44	21		
Employment Status				
Unemployed	19	5	.001	.982
Employed	60	16		
Socio economic status				
Poor	70	11	14.147	.000
Middle	9	10		
Alienation of subject from the family				
No	26	5	.643	.423
Yes	53	16		
Homelessness				
Yes	60	19	2.110	.146
No	19	2		
Injecting frequency in the preceding three months				
Nil	35	7		
⩾2/day	37	12	1.178	.758
Once a day	5	1		
2-5 times a week	2	1		
Needle Sharing in the preceding three months				
No	38	23	5.756	.016
Yes	33	6		

the history of ever been to prison ($\chi2=17.212$; p<.001) (Table 4) and suicidal attempts (SA) were found to be significantly associated with literate ($\chi2=4.262$; p=.039), unemployed ($\chi2=13.610$; p <.001) (Table 4) Furthermore, acquisitive crimes were significantly associated with homelessness ($\chi2=5.884$; p=.015), and PWID with the history of ever been in prison ($\chi2=15.508$; p=.000) (Table 5) No other significant differences were found between other study variables.

Discussion :

This study was designed to assess the magnitude of medicolegal issues and their determinants among PWID receiving opioid substitution therapy (OST) at New Delhi. In addition, the extent of the crimes committed under the influence of substances was also assessed. The major findings are that about 48% of PWID self-reported having criminal activities, and acquisitive crimes were the most common type of crime, followed by violent crimes. Suicidal ideations were seen among 29% PWID, and NSSI was reported by 21% PWID.

Although drugs and violence are a long - debated issue, it is hypothesized that they are interconnected in three ways. Firstly, psycho-pharmacological violence can be explained by the altered psycho-physiological effects of the brain due to alcohol or drug use. Further, poly-substance use often results in severe psychotropic effects on the brain and leads to extremely violent behaviour among the substance users and tends them to commit violent crimes.[6,9] Secondly, the economic compulsive model. Here, PWID may commit economically oriented crimes such as robbery and selling drugs to purchase drugs. Thirdly, systemic violence, which is an inherent part of any illicit drug market. In this model, violence is more common in the form of assault or murder between drug dealers to sustain in the drug market.[6] In this study, nearly half (n=48, 48%) PWIDs were reported to have had past involvement with the legal system in the form of warrants, arrests, detentions, convictions, probation, or parole. This is an essential finding in the understanding of the gravity of legal issues among PWIDs. The findings are in line with a study from Iran.[17] However, studies from Spain[18] and America,[19] Brazil[20] have reported a much higher percentage of PWIDs in conflict with the law.

Harm reduction programs are the mainstay cost-effective approach to reduce the criminality among the PWID,[21] which is evident from a Canadian cohort study that showed about 33% and 35% reduction in violent and nonviolent crime rates within the first two years of OST initiation.[22] A Norwegian study also found that crime rates decrease before OST's initiation and increase before discontinuation of OST.[23] Further, a decline in the number of charges for illicit drug possession following OST was also documented.[24] In contrast, a study from the US found no significant drop in the criminal charges among PWID after initiation of treatment with buprenorphine, except for the > 6 months opioid negative group.[25] Attrition, interruptions, lack of intense monitoring, relapses, compliance, premature dropouts are posing significant challenges in OST to achieve its goals to lessen morbidity, mortality, and criminal charges.[23,25]

Type of Crimes Committed:

Opioid or heroin use is generally implicated in nonviolent property crimes compared to other substances such as alcohol and cocaine.[27,28] Our study also shows that results showed preponderance for acquisitive crimes such as stealing, pickpocketing by PWID than drug-related offences and violent crimes. However, a German study has documented that drug-related offences were the most common among opioid dependents receiving opioid maintenance therapy.[28]

Frequency of Committing Crimes:

Nearly half of the crimes were committed more than once a week, followed by once a week (45%) frequency. Poor socioeconomic status was significantly associated with the increased frequency of crime (p<.001). This could stem from the fact that poor PWID tends to commit multiple crimes to procure drugs and sustain their injecting practices.

Accident Under Influence of Drugs:

Though alcohol and cannabis are commonly implicated in driving under the influence, opioids are not uncommon among drivers. Estimates showed that between 10 % and 44 % of injured

Table 4 : Suicidal ideations and suicidal attempts among people who inject drugs.

Variables	Suicidal Ideations No	Yes	Chi squarep	value	Suicidal Attempts No	Yes	Chi squarep	value
Age Group								
Young Adults	31	14			38	7		
Middle-aged	36	14	.318	.853	45	5	1.410	.494
Old adults	4	1			5	0		
Marital Status								
Married	28	13	.247	.619	36	5	.003	.960
Unmarried	43	16			52	7		
Family Type								
Nuclear	69	29	.834	.361	86	12	.278	.598
Joint	2	0			2	0		
Education								
Illiterate	27	8	.987	.321	34	1	4.262	.039
Literate	44	21			54	11		
Employment								
Unemployed	20	4	2.333	.127	16	8	13.610	<.001
Employed	51	25			72	4		
Socio economic status								
Poor	60	21	1.957	.162	71	10	.048	.826
Middle	11	8			17	2		
Alienation of PWID from the family								
No	26	5	3.615	.057	28	3	.230	.632
Yes	45	24			60	9		
Homelessness								
Yes	54	25	1.279	.258	71	8	1.250	.263
No	17	4			17	4		
Prison History								
No	62	14	17.212	<.001	69	7	2.333	.127
Yes	9	15			19	5		
NSSI								
No	56	23	.002	.961	70	9	.132	.717
Yes	15	6			18	3		

Table 5 : Acquisitive crimes among people who inject drugs

Variables	Acquisitive crimes No	Yes	Chi square	p value
Homelessness				
Present	45	34	5.884	.015
Absent	18	3		
Prison history				
Absent	56	20	15.508	.000
Present	7	17		

drivers are under the influence of drugs and/or alcohol, much higher than the general driving population.[29] Chronic heroin usage impairs cognitive and psychomotor skills, henceforth impairment of executive functioning and right-left discrimination, planning, time perception, spatial working memory, pattern recognition memory. The effects on performance may also persist for a year since the last usage.[29] This opioid-induced impairment may arise from the hyperpolarization mechanism, which prevents neurotransmitter release in the synapse. This, in turn, results in impairment in memory, decision making, and coordination.[30] Also, the sleep-inducing properties of opioids are believed to exert effects on driving performance.[30]

A study from Iran described more accidents among opioid and stimulant users due to diminished hazard perception, speeding, and more frequent violation of red signals.[31] It is observed that the trends are changing in driving under the influence as illicit drugs are becoming more commonly reported than alcohol.[32] An Australian study revealed that about 15% of illicit drug users admitted that they drove vehicles under the influence of illicit drugs in the past 12 months.[33] In our study, 45% of PWID self-reported to had met with an accident under the influence of substances. However, caution is needed while interpreting these results because most PWID were poor and sustained injuries either as a pedestrian or while driving rickshaws under the influence of substances.

Suicidal Ideations and Suicidal Attempts in Preceding Year:

Suicide is a multi-dimensional issue with physiological, psychological, social, cultural, and environmental factors. Substance use is infamous for elevated suicidal thoughts and is the second most common precursor for suicide (following depression).[34] Suicide as a risk of opioid dependence constitutes about 671,000 disability-adjusted life years (DALYs).[35] It is roughly estimated that opioid users have 75% more suicidal plans

and are twice as likely to attempt suicide than non-opioid users. Further, suicide attempts are relatively higher among the older population than younger ones.[36] A systematic review by Colledge et al has found that about 60 % of PWID had moderate to severe depression, and one in six PWID attempted suicide in the previous year.[37] It is also suggested that substance use and mental health problems are increasingly common among people leaving prison and joining the community.[38,39]

The depression in opioid users is usually due to distressing health conditions, mental disorders, family issues, and the stigma associated with opioid use, resulting in suicide.[40] A growing literature suggests that previous suicidal attempts, non-fatal suicidal behaviours, and suicidal ideations are significant predictors for completed suicide in the future.[41,42] In a review by Darke et al., it was estimated that heroin users are at risk of 14 times the increased risk for death from suicide compared to the general population.[43] A study from the US noted that 27% of PWID had thoughts of committing suicide in the past six months.[44]

Psychosocial stressors such as unemployment, homelessness, poor education, chronic injecting drug use, poor physical and mental health, substance use among the family members, alienation from the family, or social isolation result in severe mental distress culminating in suicidality among PWID.[14,45] Further, a low sense of belonging, loneliness and burdensome on family members also play a detrimental role in suicidality.[46] In our study, 29% of PWID self-reported had suicidal ideations, and 12% PWID had attempted suicide in the preceding year. Importantly, homelessness or alienation from the family was significantly associated with suicidal ideations and poor socioeconomic status ($p < .05$), and unemployment ($p < .001$) was significantly associated with suicidal attempts. This is likely due to the sense of detachment from close relationships, which is one of the crucial interpersonal-psychological precursors for severe suicidal behaviours.[47] The feeling of connectedness with other people, for example, friends and family members, is imperative in preventing suicidal ideations.[41]

Nonsuicidal Self-Injuries:

Diagnostic statistical manual (DSM)-5 defines NSSI as the "deliberate self-inflicted injury of one's own body that is neither socially endorsed nor intended to lead to death"[48,49] The most common methods employed are cutting the skin, burns, banging the head, scratching the wounds, and self-biting.[50] The prevalence of highly distressing life events among PWID, including unemployment, homeless environment, legal issues, injuries or disease, childhood traumatic events such as maltreatment, predispose them for NSSI.[37] It is worth noting that NSSI might also predict underlying suicidal ideations.[34] Substance users belong to the urban population, low literacy and low socioeconomic status are associated with the higher prevalence of NSSI,[34] which is also evident from our study results.

Limitations:

The limitations of the present study are inherent to the cross-sectional study design. For instance, we did not compare the pre- and post-opioid substitution therapy effects on medicolegal issues. Another limitation was the small sample size due to PWID recruitment from our tertiary care centre alone. A larger sample size could have had better generalization. Further, the self-reported data from the PWID by recollecting the events that happened in the past might pose a possibility of recall bias. However, the self-reported data were generally reliable among people seeking treatment, especially the young.[51]

Conclusion :

The present study provides additional evidence concerning the higher prevalence of medicolegal problems, including criminal activity, accident, suicidality, and NSSI among PWID. Illiteracy, unemployment, poor socioeconomic status, and homelessness were noted to be the significant determinants. Strict adherence to OST is of paramount importance to mitigate violent and nonviolent crimes. Since NSSI and SI are known to trigger suicides among PWID, routine screening and counselling should be encouraged. More attention should be paid to lifestyle change, social assistance programs, and family-based or community-centred rehabilitation. Future studies with a larger population are needed to bolster these findings and thereby benefit the PWID.

Declarations:

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Conflict of Interest: The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

Sex Determination from Morphometry of Sternal End of 4th Rib at Autopsy

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Abstract :

Identification of an individual from skeletal remains is one of the important aspects of forensic examination. Determination of sex from the bones is one of the parameters which could help in the identification of the deceased in cases of mutilated or amputated body fragments brought for medico-legal examination. The aim of the present study was to evaluate the sexual dimorphism of the sternal end of the right 4th rib based on morphometric traits like maximum superior-inferior height (SIH) & maximum anterior-posterior breadth (APB) in 200 dead bodies (100 male & 100 female) brought to the mortuary of Maulana Azad medical college and associated hospitals, Delhi. The results showed SIH has the highest sex differentiating potential with 88.5% accuracy compared to anterior-posterior breadth with 78.5 % accuracy.

Keywords : Sex differentiation; Superior-inferior height; Anterior-posterior breadth; 4th rib.

Introduction :

Identification is the determination of the individuality of a person – living or dead, it may be absolute (complete, full) or partial (incomplete, probable, circumstantial).[1] When establishing the identity of an individual, the primary characteristics of identification are age, sex, and stature.[2] Although all human beings throughout the world belong to the same species; *Homo sapiens,* no two people in the world are alike in their measurable characters.[3] Anthropometric characteristics have a direct relationship with sex, shape & form of an individual and these factors are intimately linked with each other. Anthropometric characteristics are manifestations of internal structure and tissue components which in turn, are influenced by environmental and genetic factors. Anthropometric data are believed to be objective, and they allow the forensic examiner to go beyond subjective assessments such as ´similar' or ´different'. With measurement data, the examiner can quantify the degree of difference or similarity and state how much confidence can be placed in this interpretation.

Determination of sex from the human skeleton is among the most important aspect of establishing the biological profile of unknown individuals. In case of mass disasters such as armed conflicts, terrorist massacres, airplane crashes, war-related crimes etc., when badly decomposed, mutilated, or damaged human remains consisting of only a few bones or their fragments are recovered from the site. In such cases, it becomes crucial to establish the biological identity, especially the sex of a missing individual because of differences in the age of epiphyseal fusion and differences in formulae for stature estimation in both sexes.[4] Accurate sex determination thus, provides valuable evidence to a forensic scientist with regard to the identification of remains.

Following death, the human body shows destructive effects of putrefaction and decomposition, but the osseous skeleton is the only structure that resists this effect for a longer time by maintaining its morphological features long after the soft tissues have been destroyed. Thus these persistent morphological features of the skeleton will help in establishing primary criteria of identification viz. age, sex, stature, and race to a certain extent.[2]

Determination of the sex of an adult deceased is not a difficult task when a complete or almost complete skeleton is available for examination. However, it becomes difficult to determine the sex of the deceased if a single bone or only a few bones are available, as the nature and completeness of a skeleton available for examination vary widely from well preserved full skeleton to a scanty material with few bones only. Thus the accuracy of the assessment of the sex of a skeleton is directly proportional to the number of bones available.[5]

The determination of sex via examination of sexually dimorphic features has been focused primarily on the pelvic girdle, long bones, and the skull. A study by Krogman showed that he scored 100 percent accuracy using the whole skeleton, 95 percent on the pelvis, 98 percent on the pelvis and skull, 92 percent on long bones, and 98 percent on long bones and pelvis.[6] In cases, where the pelvis and skull are not always available for study, or are too damaged for examination, alternative methods of sex determination are required. Several studies had demonstrated that other than the skull, pelvis, and long bones elements of the axial skeleton such as the vertebrae, sternum, and metacarpals also yield reliable results for sex discrimination.

Often an expert must extract as much information as possible from such limited and heterogeneous materials available in the

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form of fragmentary skeletal remains; then even a single bone like the sternal end of the fourth rib becomes important from a forensic anthropological viewpoint.[7] The sternal end of the fourth rib has drawn considerable attention in studies related to sexual dimorphism. Like other skeletal remains, it also presents population-specific morphometric features.[8]

The current research evaluates the sexual dimorphism of the sternal end of the fourth rib on right side in the population of Delhi, by applying discriminant function analysis, on the morphometric traits; Superior inferior height and anterior-posterior breadth.

Material and Methods :

Rib samples were collected from 200 hundred (100 males & 100 females) dead bodies brought for medico-legal postmortem examination to the department of Forensic Medicine, Maulana Azad medical college and associated hospitals, Delhi after getting ethical clearance from institutional ethics committee. Cases with known age & sex in between 18 years to 65 were included in the study. Cases with fractured, diseased/deformed right 4th rib were excluded from the study. After getting informed consent from the legal guardian of the deceased, demographic details (Age & Sex) of the deceased were recorded. The cases were categorized into 2 age groups: Group A (18 – 30 years) and Group B (31 to 65 years) each comprising 50 males & 50 females.

Procedure: After opening the thorax in routine autopsy technique sternal end of the right 4th rib was removed after identifying and by cutting 2 inches (5cm) long portion along with the costo-chondral junction with the help of rib cutter. The cut portion was boiled in a solution containing caustic soda, sodium chloride and detergent for 15 minutes or until the soft tissue's coverings were removed. Following this rib was cleaned and dried at room temperature.

Measurements: With help of vernier caliper maximum superior-inferior height (SIH) & maximum anterior-posterior breadth (APB) were measured to the nearest tenth of a millimeteras shown in photograph 1 & 2. Three readings were taken and average of the results recorded. All measurements were measured keeping the bone in anatomical position. All measurements are recordings in millimetres.

Table 1 : Showing group statistical analysis in both sexes

Age Group	Sex	N	Variables	Minimum	Maximum	Range	Mean	Std. Deviation	Std. Error Mean
Group A (18-30 years)	Male	50	SIH	13.1	18.5	5.4	15.872	1.3695	0.1937
			APB	5.3	8.8	3.5	6.722	0.8940	0.1264
	Female	50	SIH	9.1	15.4	6.3	12.510	1.2927	0.1828
			APB	4.0	6.8	2.8	5.514	0.5559	0.0786
Group B (31-65 years)	Male	50	SIH	12.6	19.1	6.5	16.388	1.5181	0.2147
			APB	5.2	9.1	3.9	6.974	0.8103	0.1146
	Female	50	SIH	11.2	15.9	4.7	12.994	0.9599	0.1357
			APB	4.2	6.9	2.7	5.774	0.5837	0.0826
Combined Group (18-65 years)	Male	100	SIH	12.6	19.1	6.5	16.130	1.4616	0.1462
			APB	5.2	9.1	3.9	6.848	0.8583	0.0858
	Female	100	SIH	9.1	15.9	6.8	12.752	1.1586	0.1159
			APB	4.0	6.9	2.9	5.644	0.5819	0.0582

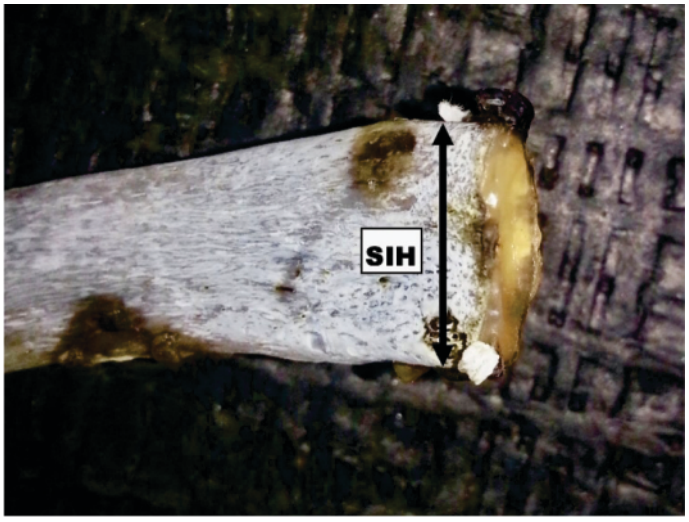

Fig. 1 : Measuring superior inferior height of sternal end of 4th rib on right side

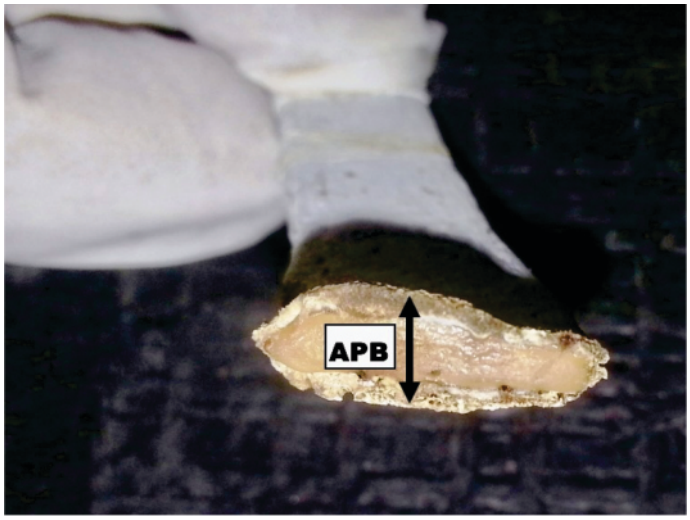

Fig. 2 : Measuring anterior posterior breadth of sternal end of 4th rib on right side

Statistical Analysis: To control the effect of age on sexual dimorphism, the sample was analysed in three age groups: Group A (18 – 30 years), Group B (31 – 65 years) and Combined (18-65 years). The data was summarized as mean and standard deviations. Students 't' test was used to compare the data. Discriminant function analysis was done using SPSS software to examine the dimorphism in sternal end of 4th rib and how the variables could correctly assign the bones to the proper sex. P value of less than 0.05 was considered significant.

Observation and Results :

The study was conducted in the department of Forensic

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Table 2 : Independent samples test for sternal end of right 4th rib in all age groups.

Age Groups	A= Equal variances assumed B= Equal	Levene's Test for Equality of Variances	T-test for Equality of Means								
			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
										Lower	Upper
Group A (18 – 30 years)	SIH	A	0.449	0.504	12.623	98	0.000	3.3620	0.2663	2.8335	3.8905
		B			12.623	97.676	0.000	3.3620	0.2663	2.8334	3.8906
	APB	A	18.259	0.000	8.114	98	0.000	1.2080	0.1489	0.9125	1.5035
		B			8.114	81.958	0.000	1.2080	0.1489	0.9118	1.5042
Group B (31 – 65 years)	SIH	A	10.816	0.001	13.361	98	0.000	3.3940	0.2540	2.8899	3.8981
		B			13.361	82.780	0.000	3.3940	0.2540	2.888	3.8992
	APB	A	4.965	0.028	8.496	98	0.000	1.2000	0.1412	0.9197	1.4803
		B			8.496	89.064	0.000	1.2000	0.1412	0.9194	1.4806
Combined Group (18 – 65 years)	SIH	A	6.242	0.013	18.112	198	0.000	3.3780	0.1865	3.0102	3.7458
		B			18.112	188.196	0.000	3.3780	0.1865	3.0101	3.7459
	APB	A	17.152	0.000	11.611	198	0.000	1.2040	0.1037	0.9995	1.4085
		B			11.611	174.142	0.000	1.2040	0.1037	0.9993	1.4087

Table 3: Standardized Canonical Discriminant Function Coefficients (SCDFC) and Structure Matrix (SM)

	Group A (18-30 years)		Group B (31-65 years)		Combined Group (18-65 years)	
	SCDFC	SM	SCDFC	SM	SCDFC	SM
SIH	0.855	0.967	0.853	0.962	0.859	0.969
APB	0.278	0.622	0.293	0.612	0.270	0.621

Table 4: Univariate & Multivariate Discriminant Function Scores

	DF Score	% Correctly Classified
Univariate for SIH	DF = 0.758 X SIH – 10.950	88.5 % (M – 85 % & F – 92 %)
Univariate for APB	DF = 1.364 X APB – 8.518	78.5 % (M – 72 % & F – 85 %)
Multivariate	DF = SIH X 0.651 + APB X 0.369 – 11.705	89.5 % (M – 86 % & F – 93 %)

Medicine, Maulana Azad medical college, New Delhi. A total of 200 cases were taken, 100 males [50 in Group A (18-30 years) and 50 in Group B (31-65 years)] and 100 females [50 in Group A (18-30 years) and 50 in Group B (31-65 years)]. It was observed that overall superior inferior height (SIH) ranged from 9.1 mm to 19.1 mm with Mean value of 14.44 & st. Deviation of 2.144 and anterior posterior breadth (APB) ranged from 4 mm to 9.1 mm with Mean value of 6.24 & Std. Deviation of 0.948.

Group and sex wise descriptive statistics of the measurements are shown in Table No 1. It was observed that the sternal end of right 4th rib was larger in males regarding all two parameters namely superior inferior height (SIH) and anterior posterior breadth (APB).

Mean Difference Between Variables

Mean SIH in males was 16.13 mm whereas in females it was 12.75 mm with mean difference of 3.38 mm and Mean APB in males was 6.84 mm whereas in females it was 5.64 mm with mean difference of 1.20 mm. SIH has the maximum mean difference in all age groups which denotes that it has highest possibility of differentiating between two sexes followed by mean difference for APB in all age groups.

Independent Samples T Test

Independent Samples T test is done to calculate significance of means difference between SIH and APB for sternal end of right 4th rib in all age groups as shown in Table No 2.

It is observed from Table No 4 that mean of SIH and APB of sternal of right 4th rib is significantly higher in males as compare to females in all age groups. As both the variables have pless than 0.05 so null hypotheses is rejected and confirmed that both the variables have significant mean difference.

Discriminant Function Analysis for Sternal End of Right 4th Rib

Direct Discriminant Function Analysis was performed using the two variables of sternal end of 4th rib with male & female classification groups. Standardized Canonical Discriminant Function Coefficients (SCDFC) and Structure Matrix (SM) for SIH & APB of sternal end of right 4th rib are as shown in Table No 3.

Table 5 : Comparison of descriptive statistics of dimensions of SIH and APB of different populations.

S. No.	Variables				Number of cases		Population
	SIH		APB				
	Mean+ SD (M)	Mean+ SD (F)	Mean+ SD (M)	Mean+ SD (F)	Male	Fe-male	
Present Study	16.13+ 1.46	12.75+ 1.15	6.84+ .85	5.64+ .58	100	100	Indian: Central Delhi
Iscan 7	17.95+ 1.85	14.78+ 1.55	8.24+ 1.17	6.91+ 1.03	94	72	North American: White
Dupras and Pfeifer 9	12.6+ 1.9	10.4+ 1.3	6.2+ 1.1	4.9+ 1.0	27	31	British: Christ Church
Cologu et al 10	16.78+ 1.77	13.87+ 1.36	7.77+ 1.02	6.36+ 0.74	135	139	Turkish: Istanbul
Kocak et al 11	15.7+ 4.1	13.1+ 3.1	7.6+ 2.5	6.3+ 1.0	173	78	Turkish: Izmir
Wiredu et al 8	14.84+ 1.59	12.55+ 1.57	7.42+ 1.06	6.56+ 1.07	221	125	West African: Ghanaian
Gangal R et al 12	16.31+ 1.05 (16-30 years)	15.05+ 1.81 (16-30 years)	6.76+ .82 (16-30 years)	6.36+ .79 (16-30 years)	26 (16-30 years)	12 (16-30 years)	Indian: Western UP
Macaluso PJ Jr. et al 13	17.53+ 1.77	14.53+ 1.47	8.24+ 1.06	7.78+ 0.94	60	57	Spanish

Above table shows that SIH is the parameter that has higher value coefficient in all age groups so it is the best parameter for all age groups. From Stature Matrix it is evident that SIH is the parameter that more appropriately discriminates the sex.

Univariate & Multivariate Discriminant Function Score:

Univariate & Multivariate Discriminant Function Score was obtained for combined group (18 – 65 years) with cut off score zero as show in Table No 4. In cases where the DF score is less than zero, the rib is of a female and more than zero, the rib is of a male.

From above table SIH was more predictive for male and female which correctly classifies 88.5 % cases followed by APB which classifies 78.5 % cases correctly however when combined the predictive correctness was 89.5 %.

Discussion :

Ribs are flat bones which are normally 12 in pairs present on anteriorand lateral side of body and in midline they articulates with the breast bone/sternum and forms chest cage. Iscan et al introduced the rib phase technique and indicated that sexual difference in adult rib can be assessed with great reliability using the Discriminant Statistics.[7] Sex determination from the sternal end of ribs choosing the 4th rib has been carried out by various experts. But most of the researches have been done on the abroad population, regarding Indian context one study carried out by Gangal R[12] (2012) on western UP population. Present study has been carried out on mixed population of central Delhi using 200

Table 6 : Comparison of overall or individual variable % correct sex determination in different studies.

Sl. No.	Study By	% Correct Sex Determination
1.	Present Study	89.5% (overall), SIH 88.5% APB 78.5%
2.	Iscan7	83% (overall)
3.	Dupras and Pfeifer9	88% (overall)
4.	Cologu et al10	86-90% (overall)
5.	Kocak et al11	SIH 85.5% (M) 87.2% (F)
6.	Wiredu et al8	78% (overall)
7.	Gangal R et al12	60-94% (overall)
8.	Macaluso PJ Jr. et al13	86.3% (overall), SIH 83.8% APB 76.9%

cases (100 males and 100 females) of age between 18 to 65 years.

In this study, Superior inferior height (SIH) and anterior posterior breadth (APB) of sternal end of right 4th rib were used for analysis. The method of discriminant function analysis was used to evaluate how these variables could discriminate between male and female ribs and the accuracy with which these variables would assign the bone to a particular sex. Like other skeletal remains ribs also shows population specific morphometric features.[8]

Descriptive statistics of dimensions of SIH and APB of different populations studied by various experts and those of present study as described in Table no. 5 shows that ribs have population specific morphometric features. The dimensions of SIH and APB are maximum for North White American Population studied by Iscan[7] and minimum for British Population studied by Duprasand Pfeifer.[9] Cologu et al[10] observed that North American based white sex determination formulae assign many Turkish males in to a female category. So for each population we should get a particular DF score to get the appropriate results for sex determination by using sternal end of ribs.

SIH was better predictor for sex determination by sternal end of 4th rib in all the studies as shown in Table No 6.

Conclusion and Recommendations :

Based upon our observation and results of measurements the following conclusions are drawn:

1. Mean and Mean difference of the superior inferior height of sternal end of right 4th rib was higher in males as compared to females in all age groups, hence it has the highest sex differentiating potential.
2. Superior inferior height of sternal end of 4th rib is the best discriminant of sexing of the rib as it is showing up to 88.5% accuracy compared to anterior posterior breadth with 78.5 % accuracy.

This study have been limited only to age group of 18-65 years so it is recommended that further studies may be carried out considering cases of age less than 18 years and more than 65 years. In present study we used the sternal end of right 4th rib so in further studies it is recommended that ribs other than 4th rib and

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ribs of both side may be considered to know that there is any difference between measurements. Ribs are fragile bones so when any exposed body is found at any place it is recommended that during collection of skeleton forensic expert or anthropologist should be called at the site to collect these bones. The DF score is specifically designed for 4th rib so it should be identified cautiously.

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ORIGINAL ARTICLE

Pattern and Distribution of Injuries in Fatal Motorized Two-Wheeler Accident Cases - A Prospective Study

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Abstract :

In India, motorized two-wheelers are an extremely popular form of transport, and they are more commonly involved in road traffic accidents (RTAs) than other vehicles. Occupants of motorized two-wheelers are more prone to sustaining serious injuries, which are responsible for greater morbidity and mortality among them. This study was conducted to assess the pattern and distribution of injuries and the causes of death in fatal RTAs involving motorized two-wheelers. This is a prospective study of 100 cases of RTAs involving riders and pillion riders of motorized two-wheelers, which were brought for autopsy in the mortuaries of J.J.M. Medical College and Chigateri General Hospital, Davangere over 2 years. In our study, the head and neck regions were found to be most commonly involved, and abrasions were the most common external injury. Intracranial hemorrhages were found to be the most common head injury. The most commonly involved skull bone was the base of the skull, and linear (fissured) fracture was the most common type of skull fracture. The commonest intracranial hemorrhage was subarachnoid hemorrhage. Frontal lobes suffered maximum injury, and contusions were the most common brain tissue injury. The most common thoracic injuries were rib fractures. The liver was the most commonly injured solid organ. More injuries were seen in the thoracic and lumbar regions of the vertebrae. The humerus was the most common upper limb bone to be fractured. The femur was the most common lower limb bone to be fractured. Head and neck injuries were responsible for deaths in the majority of the victims.

Keywords : Fatal road traffic accident (RTA); Motorized two-wheeler accidents; Head injury; Thoraco-abdominal injury.

Introduction :

A Road Traffic Accident (RTA) is defined as an accident that takes place on the road between two or more objects, one of which must be any kind of moving vehicle.[1] According to the 2019 report of the National crime record bureau of India, 154732 persons were killed in fatal road traffic accidents (RTAs), and of these, 31093 (20.09%) were killed while riding on two-wheelers.[2] These numbers show that the riders and pillion riders of motorized two-wheelers contributed to the maximum number of deaths in RTAs in comparison to the occupants of other modes of transport.

In India, motorized two-wheelers are an extremely popular form of transport, but riding a motorcycle is more dangerous than riding a car because the body of the rider is fully exposed, without protection as compared to a car. Therefore, the victims of RTAs involving motorized two-wheelers sustain serious injuries, which are responsible for greater morbidity and mortality. Despite the revolutionary advancement in medical technology and facilities in hospitals, we are unable to stop this preventable mortality and morbidity. Therefore, there is still scope for improvement in pre-hospital and hospital facilities.

Hence, this study was conducted to know the pattern and distribution of injuries in fatal motorized two-wheeler accidental cases and the causes of death, to widen the knowledge about the common injuries and body parts involved in the victims (riders and pillion riders) and preventive measures could be formulated to reduce morbidity and mortality.

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Materials and Methods :

The present study "Pattern and distribution of injuries in fatal motorized two-wheeler accident cases - a prospective study" was conducted on 100 cases of deaths due to RTAs involving riders and pillion riders of motorized two-wheelers (with and without gear), which were subjected to medicolegal postmortem examination in the mortuaries of J.J.M. Medical College and Chigateri General Hospital, Davangere during 2 years.

Consent for collecting the required data was taken from legally authorized persons and concerned autopsy surgeons. Detailed information regarding the deceased and the circumstances leading to the death was gathered from all possible sources like police records, hospital records, investigating officers, legally authorized persons/relatives, and eyewitnesses. Ethical clearance for the present study was obtained from the institutional ethical committee of JJM Medical College, Davangere.

Observations and Results :

We studied the pattern and distribution of injuries in 100 cases of fatal motorized two-wheeler accidents, out of which 76 (76%) victims were the riders and 24 (24%) were pillion riders.

It is observed that the majority of victims (riders and pillion riders) had sustained external injuries over the head and neck

region 86 (86%), followed by upper limbs 76 (76%), lower limbs 75 (75%), thorax 51 (51%) and abdominal region 31 (31%). External injuries were in the form of abrasions, contusions, and lacerations. The commonest external injury was abrasion in various regions of the body. (Table 1)

Considering the distribution of external injuries over the combination of different body regions, the commonest regions were head–limbs, sustaining injuries in 82 (82%) cases, followed by chest–limbs in 46 (46%). Head–chest, and abdomen–limb regions were involved in an equal number of cases, i.e., 30 (30%) cases each. Head – abdomen was the next region involved in 27 (27%) cases, which was followed by chest - abdomen 30 (30%).

Table 1: Distribution of external injuries in victims (rider, pillion rider) of fatal RTAs involving motorized two-wheeler.

External Injuries	Rider [n(%)]	Pillion rider [n(%)]	Total [n(%)]
Head and neck	69 (90.7%)	17 (70.8%)	86 (86%)
Thorax	38 (50%)	13 (54.1%)	51 (51%)
Abdomen	24 (31.5%)	7 (29.1%)	31 (31%)
Upper limbs	62 (81.5%)	14 (58.3%)	76 (76%)
Lower limbs	60 (78.5%)	15 (62.5%)	75 (75%)

Table 2 : Distribution of internal injuries in the victims (rider, pillion rider) of fatal RTAs involving motorized two-wheeler.

		Rider [n(%)]	Pillion rider [n(%)]	Total [n(%)]
Internal injuries	Head & neck	74 (97.3%)	17 (70.8%)	91 (91%)
	Thorax	36 (47.3%)	9 (37.5%)	45 (45%)
	Abdomen	25 (32.8%)	5 (20.8%)	30 (30%)
	Extremities	22 (28.9%)	2 (8.3%)	24 (24%)
Head	Skull fractures	49 (64.4%)	12 (50%)	61 (61%)
	Intracranial hemorrhages	68 (89.4%)	16 (66.6%)	84 (84%)
	Cerebral injuries	20 (26.3%)	7 (29.1%)	27 (27%)
	Scalp hematoma	64 (84.2%)	15 (62.5%)	79 (79%)
Thorax	Lungs	13 (17.1%)	2 (8.3%)	15 (15%)
	Heart	4 (5.2%)	0 (0%)	4 (4%)
	Rib fracture	31 (40.7%)	9 (37.5%)	40 (40%)
	Clavicle fracture	8 (10.5%)	2 (8.3%)	10 (10%)
	Haemothorax	6 (7.8%)	4 (16.6%)	10 (10%)
Abdomen	Liver	15 (19.7%)	2 (8.3%)	17 (17%)
	Kidney	9 (11.8%)	1 (4.1%)	10 (10%)
	Spleen	10 (13.1%)	2 (8.3%)	12 (12%)
	GIT	5 (6.5%)	1 (4.1%)	6 (6%)
	Pelvic fracture	2 (2.6%)	1 (4.1%)	3 (3%)
	Haemoperitoneum	8 (10.5%)	3 (12.5%)	11 (11%)
Upper limb	Humerus	5 (6.5%)	0 (0%)	5 (5%)
	Radius	3 (3.9%)	0 (0%)	3 (3%)
	Ulna	3 (3.9%)	0 (0%)	3 (3%)
	Carpals/ Metacarpals	2 (2.6%)	0 (0%)	2 (2%)
Lower limb	Femur	11 (14.4%)	1 (4.1%)	12 (12%)
	Tibia	9 (11.8%)	1 (4.1%)	10 (10%)
	Fibula	8 (10.5%)	0 (0%)	8 (8%)
	Tarsals/Metatarsals	0 (0%)	0 (0%)	0 (0%)

Considering the internal injuries in the different regions of the body, the head & neck were the most common regions to sustain internal injuries 91(91%), followed by the thorax 45 (45%), abdomen 30 (30%), and extremities 24 (24%) (Table 2)

Among internal injuries to the head, intracranial hemorrhages 84 (84%) were the most common injury, followed by scalp hematoma 79 (79%), skull fracture 61(61%), and cerebral injuries (contusions, lacerations) 27 (27%). The most commonly involved skull bone was the base of the skull 39 (39%) followed by temporal bone 28 (28%), parietal bone 24 (24%), frontal bone 15 (15%), and occipital bone 12 (12%). The commonest type of skull fracture was linear (fissured) fracture 53 (53%) followed by comminuted fracture 11 (11%), comminuted depressed fracture 10 (10%), sutural fracture 2 (2%), and hinge fracture 1 (1%). However, the hinge fracture was not seen in pillion riders. The commonest intracranial hemorrhage was subarachnoid hemorrhage (SAH) 69 (69%) followed by subdural hemorrhage (SDH) 58 (58%), intracerebral hemorrhage (ICrH) 12 (12%), and extradural hemorrhage (EDH) 5 (5%). The cerebral injuries were in the form of contusions and lacerations. In riders, the commonest lobes which were injured were temporal 11 (14.4%) and frontal 11 (14.4%) lobes followed by parietal 8 (10.5%) and occipital lobe 3 (3.9%). In pillion riders, frontal lobe 6 (25%) was the most commonly injured part followed by temporal lobe 4 (16.6%) and parietal lobe 1 (4.1%). (Table 2)

Considering the internal thoracic injuries, rib fracture was the most common injury, seen in 40 (40%) cases. The lung was the next commonest organ to be involved 15 (15%). The heart was involved in 4 (4%) cases. Clavicle fracture and haemothorax were seen in 10 (10%) cases each. (Table 2)

Among internal injuries to the intraabdominal organs, injury to the liver 17 (17%) was the commonest finding, followed by injuries to the spleen 12 (12%), kidneys 10 (10%), gastrointestinal tract (GIT) (stomach, intestine, mesentery) 6 (6%) and pelvic fracture 3 (3%). Intraabdominal organs sustained injuries in the form of contusions and lacerations. Haemoperitoneum was found in 11 (11%) cases. (Table 2)

In the present study, vertebrae were fractured in 2 (2.6%) riders and 1 (4.1%) pillion rider of the motorized two-wheeler. Out of 76 riders of motorized two-wheeler, lumbar vertebrae were fractured in 2 (2.6%) cases. Thoracic and sacral vertebrae were fractured in 1 (1.3%) case each, whereas cervical vertebrae were not fractured in any of the riders. Out of 24 pillion riders, thoracic vertebrae were fractured in 1 (4.1%) case, whereas cervical, lumbar, and sacral vertebrae were not fractured in any of the pillion riders.

In riders of motorized two-wheeler, lower limb fractures 14 (18.4%) outnumbered upper limb fractures 10 (13.1%). In pillion riders, lower limbs were fractured in 2 (8.3%) cases, whereas upper limbs were not fractured in any of the cases.

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Among the upper limb fractures in the riders of motorized two-wheeler, the humerus was the most common bone to fracture, 5 (6.5%), followed by the radius and ulna in 3 (3.9%) cases each, and carpals/metacarpals in 2 (2.6%) cases. In pillion riders, upper limb fractures were not seen in any of the cases. (Table 2)

Among lower limb fractures, the femur was the commonest bone to fracture 12 (12%), followed by the tibia 10 (10%) and fibula 8 (8%). Tarsals and metatarsals were not fractured in any of the riders or pillion riders. (Table 2)

In our study, we observed that the majority of victims died due to head and neck injuries, comprising 70 (70%) cases. Other causes of death were multiple injuries 15 (15%), abdominal injuries 10 (10%), injury to limbs 4 (4%), and thoracic injury 1 (1%) (Table 3)

Discussion:

In our study, it was observed that the external injuries were present in all the cases 100 (100%) autopsied. Both in riders and pillion riders, the head and neck regions were the most commonly involved, followed by the extremities, thorax, and abdomen. A similar pattern was seen in the study conducted by Oberoi SS et al,[3] Singh H et al[5]and Chaudhary BL et al.[8] Our findings differ from the studies conducted by Khajuria B et al.[7] Allan A et al,[13] and Pothireddy S et al[14] who found limb injuries to be the most common.

Both in riders and pillion riders, abrasions were the commonest injury. This could be due to the dragging of victims on the road in roadside accidents. A similar pattern was seen in a study conducted by Oberoi SS et al.[3] However, Allan A et al[13] found lacerations to be the commonest injury, followed by abrasions and contusions.

In our study, it was observed that both in riders and pillion riders, internal injuries to the head and neck were seen in the majority of the cases. The high incidence of head injuries can be due to non-wearing of a helmet and the receipt of maximum force because of restricted movement of the head. A similar pattern was seen in a study conducted by Sharma BR et al.[6] In a study by Khajuria B et al,[7] limb injuries outnumbered injuries involving the head, abdomen, thorax, and spine. In studies conducted by Allan A et al[13]and Pothireddy S et al,[14] extremities were the most common regions to be involved, followed by the head and neck, chest, and abdomen.

Table 3 : Cause of death in the victims (rider, pillion rider) of fatal RTAs involving motorized two-wheeler.

Cause of death	No. of Cases [n(%)]
Head and neck injury	70 (70%)
Thoracic injury	1 (1%)
Abdominal injury	10 (10%)
Injury to limbs	4 (4%)
Multiple injuries	15 (15%)

Among the head injuries, intracranial hemorrhages were the most common, followed by scalp hematoma, skull fracture, and cerebral injuries. Pothireddy S et al[14] though found a similar result in terms of the percentage of intracranial hemorrhages, skull fractures, and cerebral injuries, scalp hematoma was the commonest injury. Bairagi KK et al[11] found that skull fractures were present in 64% of pillion riders and only 38% of riders. In a study by Sharma BR et al[6] cerebral injuries (contusion, laceration) were observed in 58.96% of victims. Chaudhary BL et al[8] found that skull bone fractures were the most common, seen in 76.71% of cases.

In both riders and pillion riders, the most commonly involved skull bone was the base of the skull, followed by the temporal bone, parietal bone, frontal bone, and occipital bone. But in pillion riders, an occipital bone fracture was more common than a frontal bone. These results differ from the study conducted by Chaudhary BL et al[8] in which among the skull bones, temporal bone fracture was the maximum (29.78%) followed by parietal (25.50%). The base of the skull, frontal, and occipital bones were involved in 21.27% each. In a study by Pothireddy S et al[14] parietal (44.27%) and temporal (38.16) bones were fractured more commonly than frontal (25.15%) and occipital bones (20.61%).

It was observed that the commonest type of skull fracture was linear (fissured) fracture, followed by comminuted fracture and comminuted depressed fracture. It is probably that linear (fissured) or comminuted fractures are more common in cases where the head strikes with forcible contact with a stationary surface, as in RTA or due to heavy impact by the vehicle. Our results were consistent with Pothireddy S et al[14] study.

We observed that in total victims and riders, the commonest intracranial hemorrhage (ICH) was subarachnoid hemorrhage (SAH). However, in pillion riders, the incidence of subdural hemorrhage (SDH) was greater than the SAH. Similar results were found by Manish K et al,[15] chandra et al[16]and Tyagi et al[17]in their studies. Our findings differ from the studies conducted by Sharma BR et al,[6] Khajuria B et al,[7] chaudhary BL et al[8]and Shivakumar BC et al[10] who reported SDH to be the commonest type.

We observed that among all head injury cases, in 27% of cases, brain tissue was injured. Of all the brain tissue injuries, contusions were more prevalent than lacerations in all the lobes of the brain. The frontal lobes suffered the maximum injury, followed by the temporal, parietal, and occipital lobes. A similar pattern was found in the studies conducted by Shivakumar BC et al[10] and Pothireddy S et al.[14] Our findings were in contrast to the observation of Chaudhary BL et al[8] who observed that among all head injury cases, in 1.5% of cases, brain tissue was injured and lacerations were more common than contusions.

The commonest thoracic injury in riders was rib fracture, followed by injury to the lungs, clavicle fracture, and injury to the heart. A similar pattern was seen in pillion riders, but an injury to the heart was not seen. Similar results were found in the studies conducted by Sharma BR et al,[6] Chaudhary BL et al,[8] Bairagi KK et al,[11] and Pothireddy S et al.[14] Our findings differ from the results

of the study conducted by Moskal A et al[9] in which among the riders, the lungs were the most frequently injured intrathoracic organ, followed by rib fracture and injury to the heart.

Among intraabdominal organs, injury to the liver was the most commonest finding. Our findings were consistent with the studies conducted by Sharma BR et al,[6] chaudhary BL et al[8], Bairagi KK et al[11] and Pothireddy S et al.[14] But, in a study conducted by Moskal A et al[9] spleen injury was found in more cases, followed by injuries to the liver, kidney, and gastrointestinal tract.

Vertebrae were fractured in 2.6% of riders and 4.1% of pillion riders, and the most commonly involved regions were the thoracic and lumbar spine. Our findings are consistent with the studies conducted by Singh H et al[5], Sharma BR et al[6], Khajuria B et al[7], Chaudhary BL et al[8] and Pothireddy S et al[14]. More injuries to the thoracic spine in the occupants of motorized two-wheelers may be attributed to the hyperflexion of the spine on impact with objects or run-over injuries.

Lower limbs and upper limbs were fractured in 16% and 10% of cases, respectively. A similar pattern was obtained in the studies conducted by Sharma BR et al[6], Aslam M et al[12] and Pothireddy S et al[14]. Motorcyclists remain vulnerable to extremity injuries. Injuries to limbs can be attributed to the free mobility and reflex action of limbs, partial covering of lateral regions of the chest and abdomen by upper limbs. A higher risk of injuries to the lower limbs can be attributed to landing on the lower limbs receiving the first impact, the weight of the motorcycle, and dragging at the time of the accident.

Among upper limb bones, the humerus was the most common bone to be fractured, followed by radius/ulna and carpals/metacarpals. Similar results were observed in the studies conducted by Sharma BR et al,[6] Chaudhary BL et al[8], and Pothireddy S et al.[14] But the findings differed from the studies conducted by Aslam M et al[12] who found fractures of the radius in most of the cases, followed by humerus, ulna, and carpals/metacarpals fractures. In a study by Allan A et al,[13] in riders, carpals/metacarpals were fractured in the greatest number of cases followed by radius/ulna and humerus fractures, while in pillion riders, radius/ulna was fractured in the greatest number of cases followed by carpals/metacarpals and humerus fractures.

Among lower limb bones, the femur was the most common bone to be fractured, followed by the tibia and fibula. Our findings were in accordance with the study conducted by Sharma BR et al,[6] Chaudhary BL et al[8] and Pothireddy S et al.[14] But our findings differed from the study conducted by Aslam M et al[12] and Allan A et al[13] in which the tibia/fibula was fractured most commonly, followed by the femur and tarsals/metatarsals.

Head and neck injuries were responsible for the death of the majority of the victims. Since the cranial cavity contains the brain with its all vital centers for the life, trauma to this region challenges the integrity and viability of the individual. Because of its size and anatomic position, it is a major site of trauma in road accidents. Other causes for the fatalities were multiple injuries, abdominal injuries, injury to limbs, and thoracic injury. Our findings were consistent with the studies conducted by Oberoi SS et al,[4] Singh H et al,[5] Khajuria B et al,[7] Chaudhary BL et al[8] and Pothireddy S et al.[14]

Conclusion :

Amongst all traffic accidents, road traffic accidents (RTAs) claim the largest toll on human life and tend to be the most serious problem throughout the globe. If we cannot prevent them, an effort may be made to decrease the incidence of RTAs by strict implementation of road safety measures and by increasing the awareness of road users about safety-oriented road behavior. This study highlights the need for urgent steps to establish good pre-hospital care and the provision of trauma services at the site in India. A nationwide computerized trauma registry is an urgent requirement to bring out the risk factors, circumstances, and chain of events leading to accidents and will be extremely helpful in policy making and health management at the national level in India. A collective effort from good governing bodies, NGOs, schools, and community education, with better implementation of traffic policies (wearing a helmet by rider & pillion rider, following traffic rules) and good roads, would help in curbing this menacing issue worldwide.

Ethical Clearance: Ethical clearance was obtained from the Institutional Ethics Committee, J J M Medical College, Davangere before the study. Confidentiality was maintained.

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Conflict of interest: The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

Study of Sexual Assaults among Minor Victim Girls

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Abstract :

The rights of children which include the right to live, the right to health care and the right to protection from economic and sexual exploitation are at jeopardy. The basic objective of the study was to analyze the factors that make the minor girls to be victimized and to reveal the diversity of genital injuries amongst the minor survivors of sexual assault. Among all victim girls below 18 years coming to the department under POCSO Act, the details pertaining to age, religion, literacy, socio economic status, site and place of incidence, time interval between incidence and medico legal examination, number of assailants and relationship with assailants were noted. The victimized children were examined to ascertain the types of sexual abuse along with the pattern of the physical and genital injuries. Three out of four perpetrators of such crime happen to be close acquaintance, accomplish or relative. Two third of recent hymen tears were encountered in pre pubertal age groups where statistical significance ($p<0.001$) was also noted. This study will enhance the awareness of health care providers, policy makers, police personnel, counsellors and all other community members.

Keywords : POCSO Survivors; Medico legal examination; Hymen tears.

Introduction :

The children are the inheritance of the world. Childhood is the blueprint of the adult and the golden period of life. Violence affects lives of millions of children worldwide in all socioeconomic and educational classes leading to many physical, social and psychological problems. India has registered a rising incidence of reporting of rape in the last 4 years which shows an increase of 14% in 2014, 21% in 2015, 23.5% in 2016 and 26% in 2017.[1]

Rape is still an under reported crime in India because of its social stigma. As per national crime records bureau (NCRB 2017) data, victim often know the perpetrators in 98% cases.[2] In the aftermath of the highly debated ghastly sexual violence of Delhi in 2012, India's public conscience suddenly awoke to face the dirty truth of child sexual abuse and gender based violence. The existing legal frameworks were revisited which led to introduction of POCSO (Protection Of Children from Sexual Offences) Act 2012 and Criminal Law Amendment (CLA 2013).[3,4] Presently the medical professionals are guided by provisions under the newly enacted laws. This study was taken up in view of the ever increasing load of the alleged sexual offences despite enhancing the ambit of the law and the punishment there of POCSO (Protection of Children from Sexual Offences) Act, 2012 is the first legislation in India to exclusively cover the child sexual abuse. It was enacted to not only protect children from offences of sexual assault , sexual harassment and pornography but also to ensure a child friendly procedure for the investigation and trial of these offences. As per WHO definition 1999 "Child sexual abuse is the involvement of a child in sexual activity that he or she does not fully comprehend, is unable to give informed consent to, or for which the child is not developmentally prepared and cannot give consent, or that violates the laws or social taboos of society."[5] Child sexual abuse is evidenced by this activity between a child and an adult or another child who by age or development is in a relationship of responsibility, trust or power, the activity being intended to gratify or satisfy the needs of the other person. This may include but is not limited to:— the inducement or coercion of a child to engage in any unlawful sexual activity;— the exploitative use of a child in prostitution or other unlawful sexual practices;— the exploitative use of children in pornographic performance and materials". The global prevalence of child sexual abuse has been estimated at 19.7% for females and 7.9% for males.[6] The prevalence of genital injury resulting from sexual assault has been an area of interest to the scientific and health care community since the 1970s. (Hayman, Lanza, Fuentes & Algor, 1972; Massey, Garcia & Emich, 1971; Soules, Stewart, Brown & Pollard, 1978). The work of MS Sommers emphasized that the development of the science and practice of the forensic examination has led to documentation of an increased prevalence of genital injury over time.[7] The absence of genital injury should not be used as pivotal evidence by the court of law as inferred by Bower and Dalton in their study.[8] Pillay explained in his text book, the importance of 1% to lodine blue dye test in those cases where genital injuries are suspected but are not visible.[9]

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Materials and Methods :

The study has been conducted in our department of Forensic Medicine and Toxicology, from January 2016 to December 2018. The approval for the study was obtained from the institutional ethical committee. This study included all the minor victim girls below 18yrs of age brought by police under POCSO Act for medico legal examinations. Informed consent was taken from the

victims/guardians prior to the examination. Relevant history was collected from the victim girls, parents, guardians and from their accompanying relatives. Details pertaining to age, religion, literacy, socio economic status, site and place of incidence, time interval between incidence and medico legal examination, number of assailants, relationship with assailants, types of sexual abuse and the physical and genital pattern of injuries of the minor survivors. For statistical evaluation the total number of cases are divided into two groups based on age of victim at the time of examination, one group is less than 12 years and the other group is 12 years or above. This division is done because in Indian law, a girl below 12 years cannot give consent for her medical examination, where her parent or guardian's consent is sort. A girl of 12 years or above can give valid consent for medical examination. Statistical evaluation in the study has been done using statistical package for social science (SPSS) software.

Aim of Study :

To study the pattern of sexual assaults against minor victims.

Objectives :

1. To analyze the factors that makes the minor girls to be victimized.
2. To study the demographic profile of sexually assaulted minor victims.
3. To reveal the diversity of genital injuries amongst the minor survivors of sexual assault.

Inclusion Criteria :

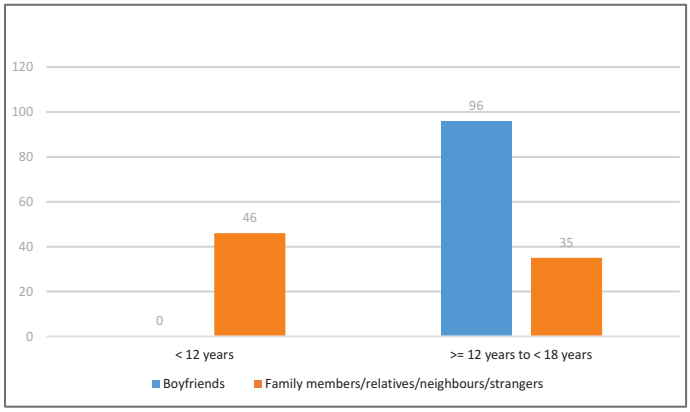
All minor victim girls brought to the department of FMT by the police with allegation of sexual offence.

Exclusion Criteria :

Those who did not give consent for medical examination were excluded.

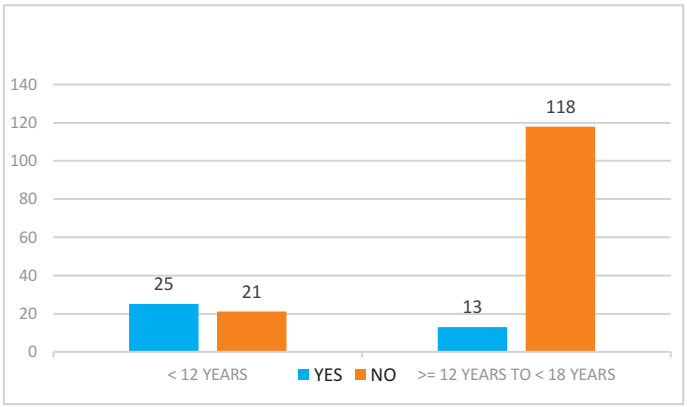
Results :

Out of 606 victims examined between January 2016 to December 2018, 272 POCSO cases were reported. Among all the 272 POCSO cases brought for examination, only 177 (65.07%) cases gave informed consent for their medicolegal examination and hence included in the study. The most vulnerable age group was found to be the adolescent age (12-17 yrs) 74.01% followed by 6-11 years (21.47%) and 0–5 years (4.52%). In comparative study there were 46 cases among below 12 years age group in comparison to 131 cases among >= 12 years group. Minor victims from low socio economic status predominate the case load (54.80%). A large proportion of victims (n=99) 55.9%had no education or had dropped out of school whereas (n=78) 44.1% were school or college going survivors. History of repeated sexual assault over a period of time was noted in 64.41% cases. In vast majority (97.18%) cases single accused was involved in rape whereas 2.82% cases were registered as gang rape (more than one assailant involved). While considering the relationship of accused with the survivors, the alleged boyfriend is the main culprit in 96 cases when the victims belong to >= 12 years of age in comparisons to the number of cases in less than 12 years age group. Whereas, the family members, relatives and strangers are the main culprits (46 cases) among less than 12 years age group in comparisons to 35 cases in 12 years or above age group [Fig – 1]. This difference in proportion of the relationship of the victims with the accused between the two groups was statistical significant ($p<0.001$). Majority of cases (68.93%) have occurred in the safe confines of houses followed by 31.07% cases in the isolated place secluded from society. Within first 96 hours of incidence, 39 cases were examined among less than 12 years girls in comparison to 53 cases in more than equal to 12 years victims. 78 cases have been examined beyond 4 days, among 12 years or above girls in comparison to 07 cases in less than 12 years age group [Table -1]. This difference in time interval between the incidents and medical examination between the two groups was statistically significant ($p < 0.001$). History of consensual sexual relation was found mostly in 12 years and above girls (n=94) in comparisons with below 12 years victims (n=0) [Table – 2]. This difference of types of assault on minor victim girls between the two age groups had statistical significance ($P < 0.001$). Genital injuries were more common than extra genital injuries. Multiple types of these injuries were also found in some cases. Recent signs of sexual assault in the form of hymenal tear and perineal



P-value is 0.000 and Chi Square value is 73.66

Figure 1 : Relationship of victim with accused



P-value is 0.000 and Chi Square value is 39.85

Figure 2 : Recent tear of hymen

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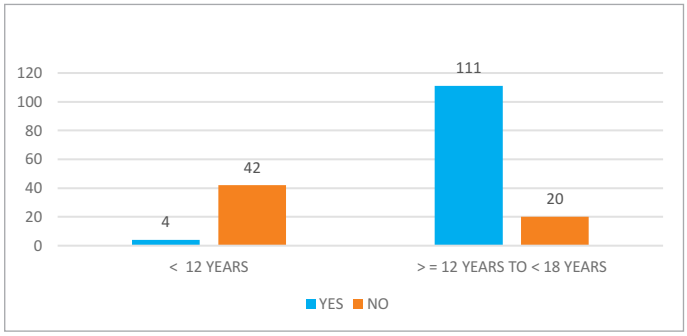
injuries were found in 17 girls among below 12 years of age group whereas in 07 cases only recent hymenal tear was seen among 12 years or above age group. All the 5 cases of perineal tear were found among the victims of below 12 years of age [Table – 3]. Similarly (n=25) 65.7% of the cases of recent hymenal tear was observed among the victims of less than 12 years as compared with >=12 years age group (n=13) [Fig – 2]. The difference in proportion among the different age group was statistically significant. Similar statistical significance (p<0.001) was also noted in old hymenal tear with 111 cases seen among 12 years or



Pvalue is 0.000 and Chi Square value is 86.49

Figure 3 : Old Tear of Hymen

Table 1 : Time Interval Between the Incidents and Medical Examinations.

Time Interval	Total No. of Casesin < 12 Years	Total No. of Cases In >= 12 Years	Chi Square Value	P Value
0 – 4 DAYS	39	53	26.797	0.000
>= 4 DAYS	07	78		

Table 2 : Types of Assault on Minor Victim Girls.

Types of Assault	< 12 Years	>= 12 Years	Chi Square Value	P Value
Consensual	0	94	70.39	0.000
Forcible sex act / Touching/Fingering	46	37		

above age group while 4 cases among girls below 12 years [Fig – 3]. As an outcome of sexual intercourse on minor victim girls, bad outcomes in the form of pregnancy, abortion, premature motherhood were found in 29 cases. Among those girls with bad outcomes, 20 survivors ended up in shelter home.

Discussion:

Incidence of POCSO cases has shown an alarmingly constant rise over the years. This may be due to heightened public awareness and efficient reporting. It is also due to increased referral to our tertiary care centre citing unavailability of lady doctors from smaller hospitals to conform to provisions of POCSO Act. In our study one third of such cases do not go to the whole way by refusing any sort of medical examination. Minor victims from low socioeconomic status predominate the case load similar to Sarkar SC etal.[10] A large representation of the

Table 3 : Pattern of Injuries Inflicted on Minor Victims.

Age group	Extra Genital injuries with recent hymen tear	No genital injuries	Genital injuries		
			Old tear of Hymen	Only Recent tear of Hymen	Perineal tear with recent hymen tear
< 12 year	8	3	4	12	5
>= 12 years	6	21	111	7	0

case load from the lower socioeconomic strata is proportionate to the socioeconomic divide in the society without any clean preponderance to any particular class. Dissociation of parents from their children might be a contributing factor. Higher opportunities of mobility and communication devices might be playing a role. Higher socioeconomic status, educated parents , small family size are interrelated and might be seen as a safety network.

The prevalence of child sexual abuse ranged from 4% - 41% in studies conducted exclusively among young women below 18 years of age.[11] Comparing the age of the victims we find 12 to 17 yrs age group were more vulnerable which is coherent with the studies by Yadukul S et al, Sarkar S C et al, Sukul Biswajit et al and Kumar Pal S et al.[10,12,13,14] very young pre pubertal girls (less than 12 yrs) constituted about a quarter of the total examined case load. More than half (60%) of the sexual abuse cases reported that the incident took place before the age of 12 as revealed in the study conducted in Brazil in 2009.[15] Experiences of seductions occurred at much earlier ages than had been previously assumed, with 81% occurring before puberty and 42% under age 7.[16] The rates of aggression were higher when sexual abuse recurred across both childhood and adolescents as per Baker et al.[17] In our study there was also repeated assault over a period of time in 114 cases but the rates of aggression was not compared. The perpetrator is a known person closely associated with victims among less than 12 years age groups as well as 12 years age group and above. In two third of the cases (n=96) (73.3%), the boyfriend is the perpetrator among above 12 years age groups, which includes consensual sex with the false promise of marriage. It showed almost similarities with studies by Kumar Pal et al (54%). According to Sushma Suri 78% victims were known to perpetrator and 22% stranger.[18] Karthiga RK et al reported that children victims know most of the perpetrators.[19] However, in contrast to this Yadukul S et al reported 80% were stranger to the child, 11.4% were neighbors and 8.6% were family members. A survey by United Nations International children education fund (UNICEF) on demography and health was conducted in India from 2005 to 2013, which reported that ten percent of Indian girls might have experienced sexual violence when they were 10 – 14 years of age and 30% during 15-19 years of age. Overall, nearly 42% of Indian girls have gone through the trauma of sexual violence before their teenage.[20]According to Irwani (2011), child sexual abuse in India has been a huge old and deep rooted social problem and child trafficking for commercial sexual abuse has

become a serious issue for policy makers.[11] In our study majority of cases occurred in safe confines of a house, similar to studies by Kumar Pal S et al and Sarkar S C et al, who have reported common place of occurrence as own house and accused's house respectively. A study by Deb & Walsh revealed sexual violence at home in 18.1% children of grade 8 and 9.[21]

In our comparative study, 52% of the total victims were examined within golden period of 96 hours. Time is an important factor during the examination, as regarding healing of injuries and destruction of biological evidence. Out of total 46 cases among below 12 years age group, 39 cases were examined within 4 days of incidence. This observation is in confirmation with findings of Kumar Pal S et al and Sarkar S C et al. We found 28% cases examined beyond 7 days while in contrast to our study, Yadukul S et al reported 54.5 % cases examined latter than 7 days of alleged incident. He reported only 17.1% cases examined within 24 hours which is similar to our study i.e. 12% within 24 hours. But Santosh et al found that 61% cases reported for medical examination within 72 hours of incident.[22] Aparna S et al shows that only 3.92% examined on the day of the incident and 21.57% victims were brought for medical examination after 2nd week – 3rd week of the incident.[23] Asmentioned by Guharaj and Gupta, the hymen tears usually heal within 5 or 6 days and become shrunken to look like small tags of tissue after a week to 10 days.[24] In our study half of the cases (59.54%)(n=78) have been medically examined beyond the golden period of 96 hours among more than and equal to 12 years age groups. The reason may be the fact that the assailant had a friendly relationship with the victim and after the mutual sexual activity, there was no lodgment of complaint. FIR was filed only when both parties failed to have mutual settlement. This delayed the lodgment of complain and hence the medical examination. Though legally invalid, 53.11% of victims are consenting partner in the act. This is in confirmation with the observation made by Sarkar S C et al.

Genital injuries involved were more common than non genital injuries, not only in our study but also in other studies by Sarkar S C et al. As per Perei S bodily injury were found in 25.9% cases.[25] According to Tailor et al, 83.7% cases had sexual intercourse with mutual consent.[26] Marks of violence is absent even in the absence of consent due to (i) Fear of injury or death leading to submission by the victim (ii) Incapacitation caused to victim by throat grips, strong neck holds or severe blow on the head (iii) Force used is insufficient to cause injury (iv) Too early examination as mentioned by Anil Aggrawal.[27] Old hymen tear (n=111) (84.7%) in a minor girl is the most common genital finding as proof of sexual act, exclusive to the post pubertal age group. Recent hymen tears (n=25) (54.35%) were encountered in pre pubertal age group (<12years) . This may be due to early reporting and examination. Chance of being sexually active is too minimal among pre pubertal age group in Indian conservative society. Studies show that in 60% of cases of rape, there may not be any injury on private parts as stated by Ignatius in his text book.[28] The present study found that (n=29)16.38% of the cases became pregnant following the act including abortion and delivery. This finding is almost coherent with the study of Biswajit Sukuletal (16.09%).[13]

Conclusion :

Care of sexually assaulted child is a multi disciplinary issue. No particular discipline can own or disown the medicolegal responsibility that comes their way in the form of a distressed victim of sexual offence. In the process of shifting the responsibility we may be guilty of wasting valuable time (golden period of 96 hours). Sexual victimization of females cannot just be wished away as the problem has a multifactorial foundation. It is not purely based on an opportunistic behavior flared by perverted male desire but rather aroused by multiple social factors along with lack of awareness about legal restrictions. Parents, teachers and relatives in the community have a vital role to protect the children from sexual exploitation and abuse, as the children are the country's greatest human resource. Because planning a complete prevention looks next to impossible hence, stress should rather be given on damage control, which means prompt medical, psychological and legal support to be made available for such survivors which is detailed in the DHR guidelines, SOP of Odisha state and guidelines given by government of India.[29,30,31] As specified in the WHO guidelines for child sexual abuse regardless of who is responsible for the medical history and the forensic interview, the two aspects of the child's evaluation should be conducted in a coordinated manner so that the child is not further traumatized by unnecessary repetition of questions and information is not lost or distorted.[5] CSA is an extensive problem and even the lowest prevalence includes a huge number of victims.[32] When sexual abuse goes unreported and children are not given the protective and therapeutic assistance they need, they are left to suffer in silence.[33] Although the reported cases of child sexual abuse is just the tip of the iceberg, we as responsible citizens have our crucial role to play. The offence of CSA is highly grave in nature and leaves the child in a state of mental turmoil and physical torture.[34] The educational system should include on (LSBE) Life Skills Based Education System and conduct classes on moral values and principles.[35] There is a need to evolve strategies to protect children from sexual abuse and the programs should address both boys and girls.[36] The union health ministry has asked all hospitals to set up a designated room for forensic and medical examination of victims of rape.[37] This study will enhance the awareness of health care providers, policy makers, police personnel, counselors and all other community members.

Conflict of Interest : None.

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ORIGINAL ARTICLE

A Histopathological Study of Vital Organs in Deaths due to Burns.

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Abstract :

Burn causes the injuries over the body. It is due to application of heat or chemical substances to the external or internal surfaces of the body. It causes destruction of the tissues, which produces histopathological changes in the tissues. It is very important to know the profile of histopathological changes in organs, commonest organ involved, correlation of duration of burns to decide the further mode of treatment. In the wake of this, it was decided to conduct prospective study of histopathological changes in the vital organs of death due to burns at Vilasrao Deshmukh government medical college, Latur, Maharashtra. Total 100 cases were selected for the histopathological study of vital organs i.e. lungs, liver, kidneys, brain and heart.

Bronchopneumonia, intra-alveolar haemorrhages, inter - alveolar haemorrhages and interstitial pneumonitis were seen in lungs among cases died with in 24 hours but it was more pronounced after 3 to 7 days of survival period. Focal haemorrhage, infarction, periportal necros is were seen in liver among cases where percentage of burns is >40 % TBSA. The necrosis and changes in sinusoids which were seen decreased as the survival period increases in liver. Cloudy degeneration, tubular casts in renal tubules of kidneys were common findings in cases with any duration of survival. Tubular necrosis was most common finding in cases with <40% of burns followed by acute pyelonephritis, it is and were more pronounce das the percentage TBSA increases. Tubular casts and cloudy degeneration were seen in kidneys, nearly at any percentage of burn. The most common findings in brain were generalized oedema in 26% cases, followed by vacuolic degeneration in 20% cases. These changes were less marked before 24 hours of survival period and found more pronounced with increase in survival period. Changes in brain were seen less marked below 60%TBSA and found more as the percentage TBSA involved increases. Most common histopathological finding in cardiact issue were interstitial oedema, focal pallor at all stages of survival period. Other changes were less marked before 3-7 days of survival period, changes were found more pronounced with increase in survival period. More pronounced changes in heart observed as there was increase in percentage of burn, particularly at TSBA 81-100%.

Keywords : Burn Deaths; Percentage of Burns; Survival Period; Histopathological Study.

Introduction :

There are different causes of death. In burns, patient dies due to immediate or late complications. Immediately patient of burn dies due to shock, smoke inhalation, etc. However if patient survived for long period it leads to the infections, biochemical disturbances and multiple organ failure due to histopathological changes in the organs like tubular necrosis in kidneys, hepatic dys function, pulmonary embolism and bron chopneumoni a in lungs, encephalopathy in brain, gastrointestinal erosions.[1,2] Causes of death after severe burn have changed over time; in the international literature, multi-organ failure (MOF), acute systemic inflammatory response syndrome (SIRS), and infection are seen as the most important causes, but the exact distribution of causes of death remains unknown.[3] When patients die, autopsy is considered to be the optimal standard to confirm clinical diagnosis. Not only does autopsy enable the clinician to verify the accuracy of the primary clinical diagnosis but post-mortem pathological findings are also relevant to medical education.[4]

Generally, patient may die early if percentage of burn is more and death is delayed when percentage of burns is less. It feels need to conduct this study to find out the exact reason or pathology that causes death very early in cases of severe burns. When patient of burn is admitted in the hospital, doctor have to impart the treatment to save the life of patient. During treatment doctor must know the probable pathologies or cellular changes occur in the tissue of the body. Till date, such type of study was not conducted to know the histopathological changes in the organs in burn cases. Hence a sincere attempt is made to study the histopathological changes in the vital organs in cases of burn deaths. It will be of immense help for further research and will guide to the surgeons during treatment of patients.

Aims and Objectives:

1. To study histopathological changes in vital organs viz. lungs, liver, kidneys brain and heart.
2. To study the histopathological changes in vital organs with respect to survival period of the burn victim.
3. To study the histopathological changes in vital organs with

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respect to the total body surface are ainvolved due to burn injuries.

Material and Methods :

A prospective, observational histopathological study was conducted at Vilasrao Deshmukh government medical college & Hospital, Latur during the period of two years from 1st October 2013 to 30th september 2015. All the cases died due to burn injury and brought for medico-legal autopsy at mortuary. The burn cases admitted and died during treatment in the hospital are included in the study. All cases brought for medico-legal post-mortem which died due to causes other than burn injury, burn cases due to electrocution, lightning, radiation, chemical burns were excluded from the study. Decomposed cases and the cases with known history of chronic diseases were also excluded from the study. 100 Cases were selected for histopathological examination using Stratified Random Sampling Method after applying exclusion criterion as above

Autopsy tables and autopsy instruments, organ preservation, carrier material used. Grossing table was used for grossing of the tissue. Tissue processor, block preparation, rotatory microtome, staining material and examining microscope were used for the histopathological study of vital organs.

Results :

Lungs - (Table-1): It is observed that most common histopathological finding in lung tissue was congestion in 68% cases followed by oedema, macrophages, haemorrhages (intra-alveolar and interstitial) observed in 58% of cases and bronchop neumonia in 19% cases (Table-01). Interstitial haemorrhages are seen within the pulmonary interstitium. It may be due to rupture of alveolar capillaries as a reaction to stress due to burns (Picture - 1). Interstitial pneumonitis is diffuse infiltrate seen in interstitium of pulmonary parenchyma. It may be result of inflammatory changes or due to sepsis produced due to burn (Picture-2). Broncho pneumonia, intra-alveolar haemorrhages, inter-alveolar haemorrhages and interstitial pneumonitis though observed in cases died within 24 hours but it was more pronounced after 3 to 7 days of survival period. These changes were suggestive of septicaemia. In cases with 81-100% burns, atelectasis, broncho pneumonia, intra-alveolar and interstitial haemorrhages, interstitial pneumonitis decreased as compared to 61-80% burns (Table - 01). So, there was a progressively less changes in cases with more % of burn involved and vice versa.

Liver (Table 2)- It is found that congestion in 48% cases, fatty

Table 1: Histopathological findings in lungs in relation with the survival period of victim & total body surface area (TBSA) (n=100).

	Findings in lungs in relation with the survival period (n=100)							**Findings in lung in relation with the percentage of burns (TBSA) (n-100)**					
Sr. No.	Duration of Survival (No. of Cases)	0-24h (24)	>1-3d (6)	>3-7d (31)	>7-14d (18)	>14d (21)	Total (100)	Percent of Burns (No. of Cases)	0-40 (10)	41-60 (26)	61-80 (28)	81-100 (36)	Total (100)
1	Congestion	18 18 %	5 5%	22 22 %	9 9%	14 14 %	68		7 7%	13 13 %	21 21 %	27 27 %	68
2	Oedema	11 11 %	5 5%	19 19 %	8 8%	12 12 %	55		7 7%	13 13 %	16 16 %	19 19 %	55
3	Atelectasis	1 1%	0	3 3%	2 2%	2 2%	08		0	4 4%	3 3%	1 1%	08
4	Broncho pneumonia	1 1%	1 1%	4 4%	5 5%	8 8%	19		1 1%	6 6%	8 8%	4 4%	19
5	Emphysema	0	0	3 3%	2 2%	1 1%	06		0	1 1%	2 2%	3 3%	06
6	Intra -alveolar hemorrhage	1 1%	2 2%	11 11 %	5 5%	7 7%	26		3 3%	7 7%	8 8%	8 8%	26
7	Interstitial Hemorrhage	4 4%	3 3%	13 13 %	6 6%	6 6%	32		2 2%	11 11 %	11 11 %	8 8%	32
8	Interstitial Pneumonitis	1 1%	1 1%	14 14 %	2 2%	1 1%	19		3 3%	6 6%	5 5%	5 5%	19
9	Macrophages	8 8%	3 3%	16 16%	6 6%	6 6%	39		5 5%	10 10 %	10 10 %	14 14 %	39
10	Hemorrhagic necrosis	0	0	3 3%	2 2%	2 2%	07		0	3 3%	2 2%	2 2%	7
11	Microthrombi	0	0	2 2%	1 1%	1 1%	04		1 1%	2 2%	0	1 1%	4

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Table 2 : Histopathological findings in liver in relation to survival period of victim and percentage of burns (TBSA) involved. (n=100)

	Liver his to pathological findings of as per survival period (n=100)							Findings of according to percentage of burns (TBSA) involved (n=100)					
Sr. No.	Duration of Survival (No of Cases)	0-24h (24)	>1-3d (6)	>3-7d (31)	>7-14d (18)	>14d (21)	Total (100)	Percent of Burns (No. of Cases)	0-40 (10)	41-60 (26)	61-80 (28)	81-100 (36)	Total (100)
1	Congestion	11 11 %	4 4%	14 14 %	7 7%	12 12 %	48		7 7%	11 11 %	9 9%	21 21 %	48
2	Fatty Change	3 3%	2 2%	10 10 %	4 4%	7 7%	26		7 7%	8 8%	4 4%	7 7%	26
3	Portal Inflammation	3 3%	1 1%	7 7%	4 4%	3 3%	18		1 1%	5 5%	4 4%	8 8%	18
4	Focal Hemorrhage	2 2%	2 2%	8 8%	6 6%	6 6%	24		0	8 8%	7 7%	9 9%	24
5	Infarction	1 1%	2 2%	7 7%	5 5%	5 5%	20		0	6 6%	8 8%	6 6%	20
6	Degenerative Changes	1 1%	1 1%	4 4%	6 6%	5 5%	18		1 1%	7 7%	7 7%	3 3%	18
7	Dilated & Congested sinusoids	13 13%	2 2%	6 6%	2 2%	3 3%	24		2 2%	3 3%	5 5%	14 14 %	24
8	Centrilobular Necrosis	5 5%	2 2%	5 5%	4 4%	5 5%	21		1 1%	5 5%	5 5%	10 10 %	21
9	Focal necrosis	3 3%	1 1%	3 3%	2 2%	1 1%	10		1 1%	2 2%	3 3%	4 4%	10
10	Periportal Necrosis	1 1%	0	1 1%	4 4%	3 3%	9		0	4 4%	3 3%	2 2%	9
11	Fibrin deposition	0	0	1 1%	2 2%	1 1%	4		0	0	1 1%	3 3%	4

change in 26%, necrotic changes (centrilobular-most common, focal, periportal) seen in 40% cases. Centrilobular necrosis is a coagulative necrosis of hepatocytes. Centrilobular necrosis is earliest change of liver in hypoxia due to any cause like burns (Picture-3). Focal haemorrhages, portal inflammation, infarction, dilated sinusoids etc were other changes observed in liver were more marked as the survival period increases except periportal necrosis and changes in sinusoids. That was suggestive of septicaemia. The necrosis and changes in sinusoids which were seen to be decreased as the survival period increases. Dilated and congested sinusoids was most common histopathological finding in first 24 hours which was seen less marked as survival period was prolonged. It showed that congestion, fatty change, portal inflammation, changes in sinusoids, necrotic changes were seen in liver at any percentage of TBSA involved. Fatty change seen in 26% of cases. Fatty liver shows infiltration of hepatocytes with eccentrically placed nuclei and abundant vacuolated cytoplasm. Fatty liver is the result of inflammatory response in burn (Picture-4). Focal haemorrhage, infarction, periportal necrosis were seen in cases with more when percentage of burns is >40 % TBSA involved and fibrin deposition seen in cases with percentage with >60% burn cases. This suggests the signs of septicaemia. changes in sinusoids, centrilobular necrosis, and fibrin deposition were found more as the percentage TBSA increases.`

Kidneys (Table-3): It showed that most common histopathological finding in kidneys was acute tubular necrosis found in 48% cases followed by pyelonephritis in 38% cases. Tubular casts observed in 31% cases and cloudy degeneration in 15% cases. Cloudy degeneration, tubular casts in renal tubules were common findings in cases with any duration of survival. Regeneration of epithelium was seen in cases with prolonged survival. Acute tubular necrosis indicates acute kidney injury as in burn injury. In ATN, there is loss of attenuation of epithelium of tubules. Tubular lumen shows sloughed off necrotic epithelial cell with fibrin deposits (Picture-5). Acute pyelonephritis is due to sepsis in case of burns. Acute pyelonephritis shows diffuse neutrophilic infiltrate in interstitium and tubular lumina along with tubular necrosis (Picture-6). It is observed that tubular necrosis was most common finding in cases with <40% of burns followed by acute pyelonephritis and were more pronounced as the percentage TBSA increases. Tubular casts and cloudy degeneration were seen nearly at any % of burn. Regeneration of epithelium was not seen in cases with 81-100% burns.

Brain (Table- 04): It is observed that in most burn deaths cases

Table 3 : Histopathological findings of kidneys in relation to survival period of victim and percentage of burns (TBSA) involved. (n=100)

	Histopathological findings of kidneys as per survival period							Findings of kidneys according to percentage of burns (TBSA) involved					
Sr. No.	Duration of Survival (No. of Cases)	0-24h (24)	>1-3d (6)	>3-7d (31)	>7-14d (18)	>14 d (21)	Total (100)	Percent of Burns (No. of Cases)	0-40 (10)	41-60 (26)	61-80 (28)	81-100 (36)	Total (100)
1	Cloudy Degeneration	3 3%	2 2%	4 4%	3 3%	3 3%	15		2 2%	5 5%	2 2%	6 6%	15
2	Tubular casts	4 4%	2 2%	11 11 %	6 6%	8 8%	31		1 1%	7 7%	11 11 %	12 12 %	31
3	Acute pyelonephritis Regeneration	7 7%	2 2%	13 13 %	7 7%	9 9%	38		4 4%	8 8%	11 11 %	15 15 %	38
4	Regeneration of epithelium	0	1 1%	4 4%	3 3%	4 4%	12		4 4%	4 4%	4 4%	0	12
5	Acute Tubular Necrosis	4 4%	3 3%	17 17 %	10 10 %	14 14 %	48		5 5%	15 15%	10 10 %	18 18 %	48

Table 4 : Histopathological findings in brain in relation to his to survival period of victim and percentage of burns (TBSA) involved. (n=100)

	Histopathological findings of kidneys as per survival period (n=100)							Findings of brain as per percentage of burns (TBSA) involved (n=100)					
Sr. No.	Duration of Survival (No. of Cases)	0-24h (24)	>1-3d (6 cases)	>3-7d (31)	>7-14d (18)	>14d (21)	Total (100)	Percent of Burns (No. of Cases)	0-40 (10 cases)	41-60 (26)	61-80 (28)	81-100 (36)	Total (100
1	Edema/swelling	4 4%	3 3%	8 8%	6 6%	5 5%	26		1 1%	0	11 11 %	14 14 %	26
2	Vacuolar degeneration	3 3 %	2 2%	7 7%	4 4%	4 4%	20		0	1 1%	4 4%	15 15 %	20
3	Loss of cellular process	2 2%	1 1%	4 4%	2 2%	2 2%	11		0	1 1%	2 2%	8 8%	11

Table 5 : Histopathological findings in heart in relation to survival period of victim and percentage of burns (TBSA) involved. (n=100)

	HP findings in heart as per survival period (n=100)							Findings of heart according to percentage of burns (TBSA) involved (n=100).					
Sr. No.	Duration of Survival (No. of Cases)	0-24h (24 cases)	>1-3d (6) cases	>3-(31)	>7-14d (18)	>14d (21)	Total (100)	Percent of Burns (No. of Cases)	0-40 (10 cases)	41-60 (26)	61-80 (28 cases)	81-100 (36)	Total
1	Interstitial edema	4 4%	2 2%	7 7%	4 4 %	8 8 %	25		0	3	7	15	25
2	Focal pallor	2 2%	2 2%	4 4%	1 1 %	2 2%	11		1 1%	1 1%	7 7%	2 2%	11
3	Perivascular myocardial necrosis	0	0	2 2%	1 1%	2 2%	05		0	0	0	5 5%	05
4	vacuolization in cytoplasm	0	1 1%	3 3%	1 1%	2 2%	07		0	1 1%	2 2%	4	04
5	Swelling of endothelial cells	1 1%	0	2 2%	0	1 1%	04		0	0	0	4	04

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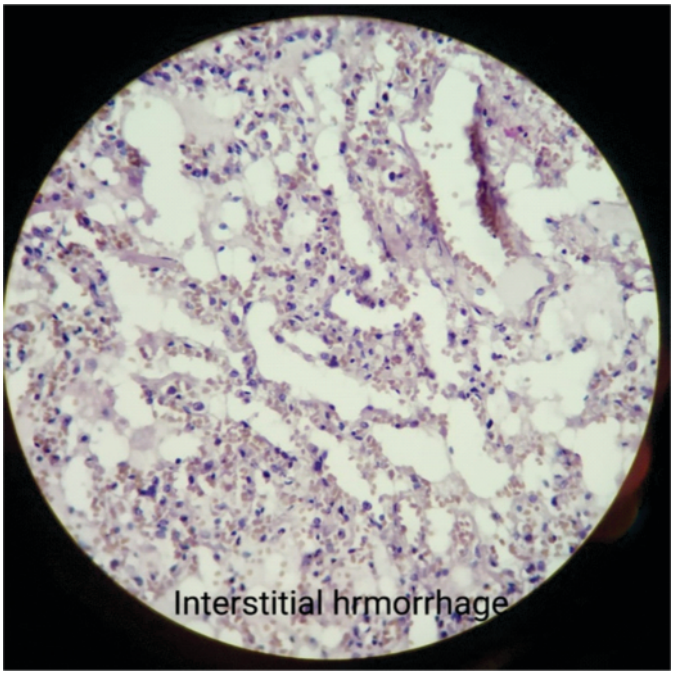

Figure 1 : Lung - Interstitial haemorrhage.

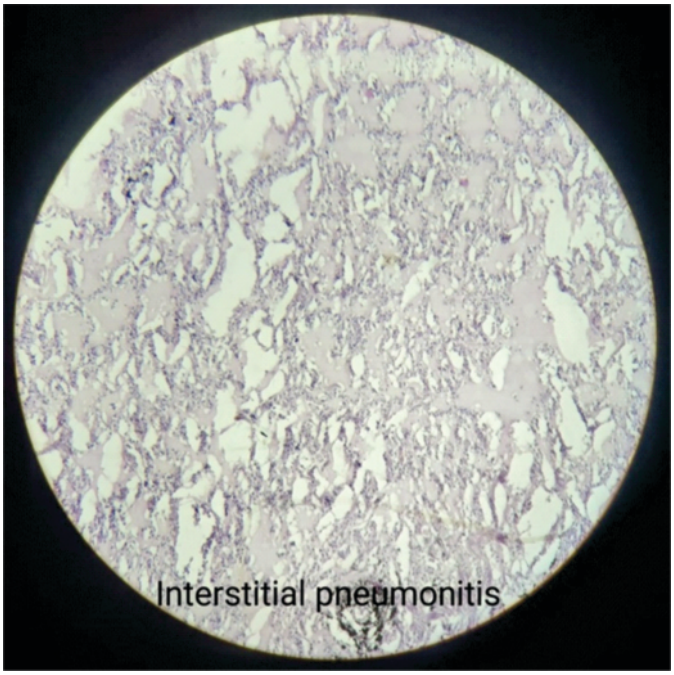

Figure 2 : Lung – Interstitial Pneumonitis.

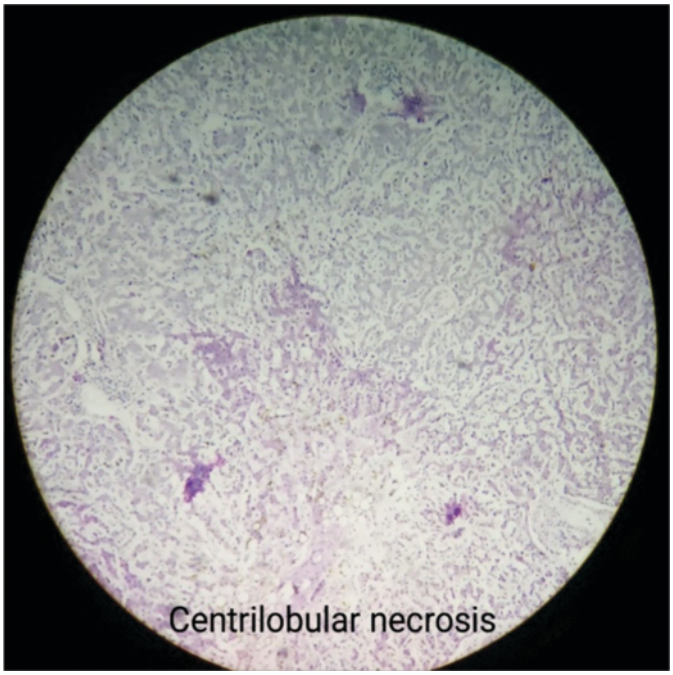

Figure 3 : Liver - Centrilobular Necrosis.

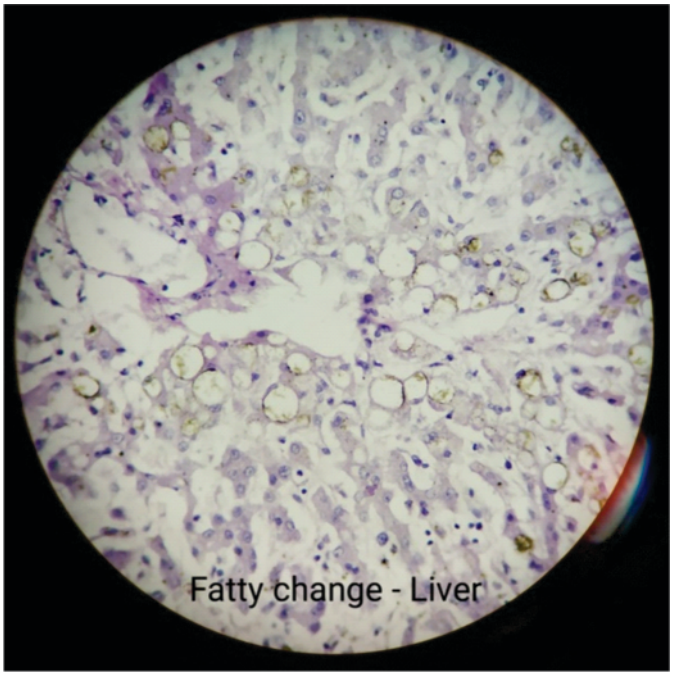

Figure 4 : Liver – Fatty Change.

there were no changes on histopathological examination of brain tissue. Most common histopathological finding found in brain was generalized edema or swelling of brain tissue found in (26) 26% cases, followed by vacuolar degeneration in (20) 20% cases. These changes were less marked before 24 hours of survival period and found more pronounced with increase in survival period except at survival period of more than 14 days where these findings were less pronounced. Table-04 showed that histopathological changes seen below 60% TBSA were less marked and found more as the percentage TBSA involved increases. Changes found more pronounced at 61 -100% TBSA involved and oedema, vacuolar degeneration were most common finding. Cerebral edema is diffuse edematous changes in neuronal cell bodies and interstitial spaces (Picture-7). Vacuolar degeneration of brain shows peripheral hydropic change in glial cells. It indicates acute brain injury (Picture-8).

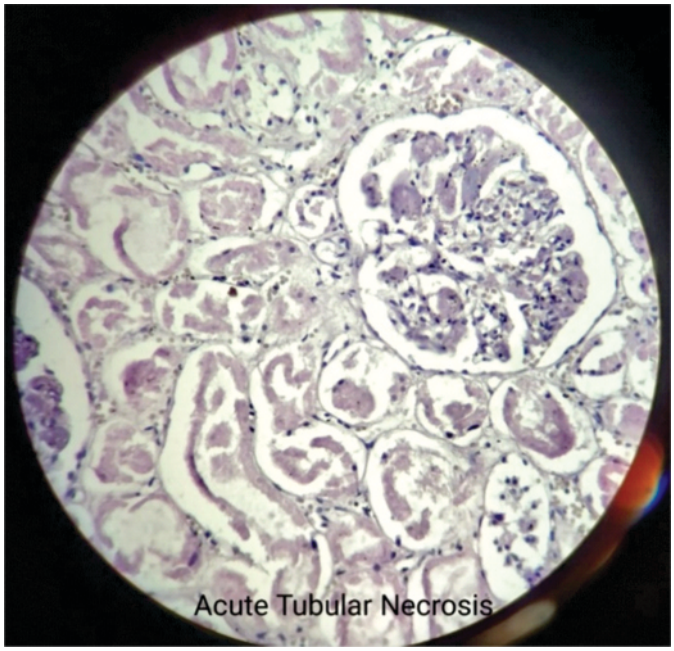

Figure 5 : Kidney – Acute Tubular Necrosis.

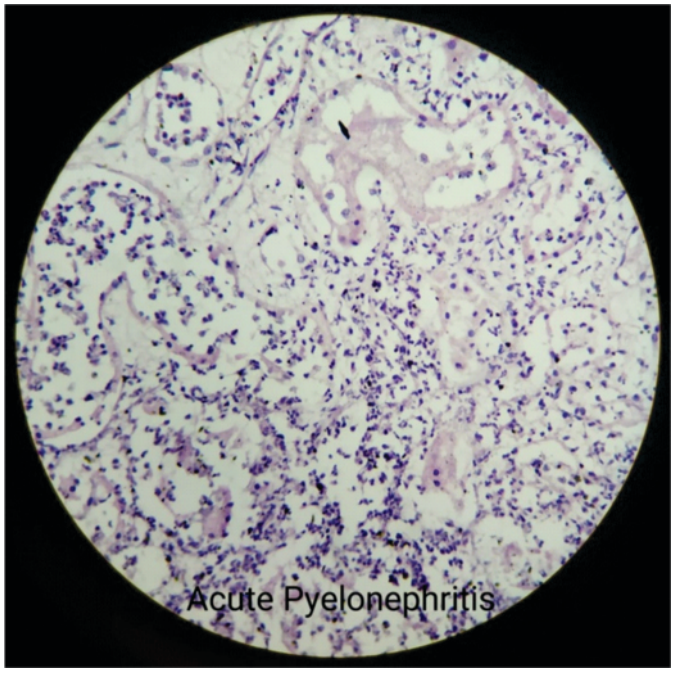

Figure 6 : Kidney- Acute Pyelonephritis.

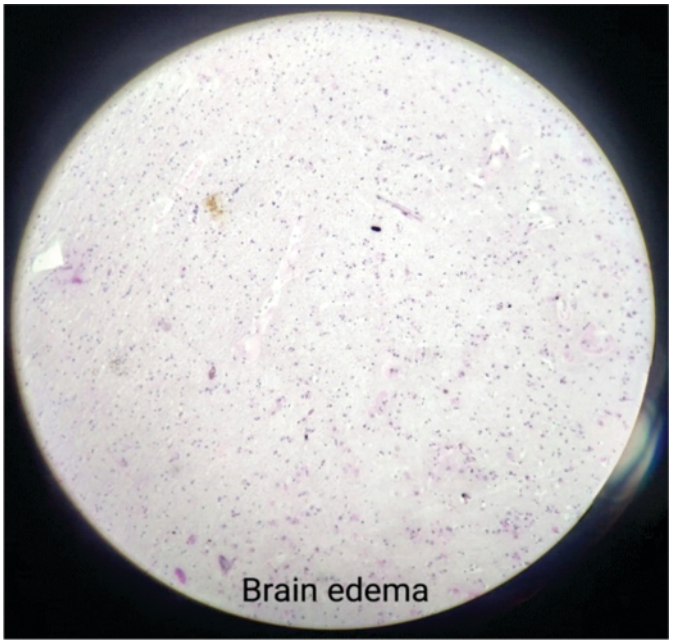

Figure 7 : Brain- Edema.

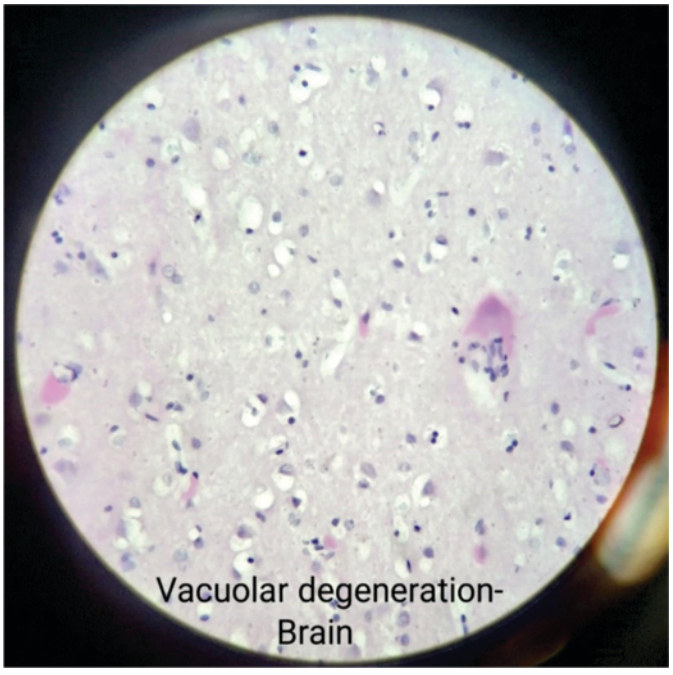

Figure 8 : Brain- Vacuolar Degeneration.

Heart (Table-05) : In study, it observed the minimal changes in examination of heart. Among the changes observed most common histopathological finding found in cardiac tissue was interstitial edema found in 25% cases followed by focal pallor in 11% and swelling of endothelial cells in 4%. Most common histopathological finding in cardiac tissue was interstitial edema and was found at all stages of survival period. It was followed by focal pallor. Other changes were less marked before 3-7 days of survival period. Histopathological changes were found more pronounced with increase in survival period. Table- 5 showed that mostly no abnormality in cardiac tissue and no change observed below 40% TBSA involvement except focal pallor in 1 case. Among changes the interstitial edema of cardiac tissue was most common finding followed by focal pallor. More pronounced changes observed as there was increase in percentage of burn, particularly at TSBA 81-100% and were suggestive of septicaemia changes.

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Discussion :

We found that most common finding in lung tissue was congestion in 68% cases followed by oedema and macrophages. Haemorrhages (intra-alveolar and interstitial) observed in 58% of cases and bronchopneumonia in 19% cases. Congestion (68%) followed by edema (55%) and macrophages (39%) were observed in lung tissue at all stages of survival period. Atelectasis, emphysema, haemorrhagic necrosis and micro thrombi seen pronounced after 3 days of survival period. Bronchopneumonia, intra- alveolar haemorrhages, inter-alveolar haemorrhages and interstitial pneumonitis were observed but more pronounced after 3 to 7 days of survival period. These changes are suggestive of septicemic changes. These findings in lungs are consistent with other studies. Shinde and Keoliya observed congestion in 73.8% cases and pulmonary edema in 55.45% cases, and Rathod et al calculated congestion in 63.8% cases, edema in 61.7% cases.[5,6] However Aragamaso found pulmonary edema in 70% burn cases. Depending on the survival period the lungs in burn shock shows diffuse interstitial edema, focal intra-alveolar edema relatively rich in proteins, focal haemorrhage, micro-thrombi containing fibrin in peripheral arteries and arterioles, focal atelectasis, focal bronchopneumonia, areas of emphysema, necrotizing bronchiolitis (agents: in particular staphylococci, streptococci, or gram negative rods) later development of so called shock lung or ventilation lung.[8]

In our study, liver congestion was found in 48% cases followed by necrotic changes in 40% cases, fatty change in 26%. Focal haemorrhages, portal inflammation, infarction, dilated sinusoids etc. were other changes observed. These histopathological changes in liver were more marked as the survival period increases except periportal necrosis and changes in sinusoids. These changes are suggestive of septicemic changes. Dilated and congested sinusoids was common finding in first 24 hours which was seen less marked as survival period was prolonged. Similar findings observed by, Shinde and Keoliya, Aragamaso and Erb et al .[5,7,9] In this study, we found that congestion, fatty change, portal inflammation, changes in sinusoids, necrotic changes were seen in liver at any % of TBSA involved. Focal haemorrhage, infarction, periportal necrosis were seen in cases with more when >40 % TBSA involved and fibrin deposition in cases with >60% burn cases. Changes in sinusoids, centrilobular necrosis, and fibrin deposition were found more as the percentage TBSA increases. Most changes seen in 81-100% TBSA involved. Similar findings were observed by Erb et al .[9] Pujari AJ, Kedare RV found liver congestion in 50.76% cases, hepatic necrosis in 49.11% cases who survived upto 3 days and regeneration in 4.60% cases in their study.[12]

Our study showed that most common change found in kidneys was acute tubular necrosis seen in 48% cases followed by Pyelonephritis in 38% cases. Tubular casts observed in 31% cases and cloudy degeneration in 15% cases. In this study we found acute tubular necrosis in 48% cases followed by pyelonephritis and these changes were more marked as the survival period was prolonged. The studies by, Sevitt S, Rathod et al, Aragamaso, Erb et al had also observed similar results.[1,6,7,9] In the study of Shinde and Keoliya who observed tubular casts as most common finding, which is not consistent with our study.[5] This may be due to difference in sample population showed that tubular necrosis was most common finding in cases with <40% of burns followed by acute pyelonephritis and were more pronounced as the percentage TBSA increases. Tubular casts and cloudy degeneration were seen nearly at any % of burn. Regeneration of epithelium was not seen in cases with 81-100% burns. The finding is similar with study by Sevitt S.[1] In the study conducted by C S Prasad, he found interstitial oedema, congestion, tubular degeneration, tubular regeneration ,vascular sclerosis, glomerular degeneration, tubular necrosis, pyelonephritis in kidneys in his study.[13]

The changes in the brain in burn shock depending on survival period includes pronounced edema, swelling, and homogenization of ganglion cells, vacuolar degeneration, loss of cellular processes; dentate nucleus, olive cells, purkinje cells, pons, and cerebral cortex are particularly affected.[8] In this study, we found that in most cases there were no changes on histopathological examination of brain tissue. Among the changes commonly observed were generalized edema or swelling of brain tissue in 26% cases, followed by vacuolar degeneration in 20% cases, which are similar with the studies of Taran A et al, Rathod et al, Aragamaso and Erb et al.[4,6,7,9] Most of the changes in brain tissue observed after 1 to 7 days of survival period. Changes found more pronounced at 61 -100% TBSA involved are oedema, vacuolar degeneration in brain. These findings are consistent with Erb et al.[9] In the study of Sathikumar M. found that the equal percentage of Grade II and Grade IV changes, 36.36% of each are observed in moderate and very severe degree of changes of alveolar oedema with congestion in lungs among the victims who survived for 8 days to 14 days.[11]

This study showed that mostly no changes in the heart. Among the changes observed, most common histopathological finding found in cardiac tissue was interstitial edema, which is in 25% cases followed by focal pallor in 11% and swelling of endothelial cells in 4% cases. At all stages of survival period cardiac tissue shows interstitial edema and it was followed by focal pallor. Other changes were less marked before 3-7 days of survival period. Histopathological changes were found more pronounced with increase in survival period. Similar findings observed by, Rathod et al, Aragamaso and Erg et al.[6,7,9]

Myocardial contractility is decreased in response to burn injury, possibly due to release of tumour necrosis factor. Cardiac instability in burn patients is associated with hypovolemia, increased afterload and direct myocardial depression. Additionally, the hyper-aggregability, hypercoagulability, and impaired fibrinolysis resulting from any acute injury may predispose to myocardial infarction.[10] We observed that more pronounced changes with increase in percentage of burn,

particularly at TSBA 81-100%. Similar findings observed by Erb et al. [9]

Conclusion :

Bronchopneumonia, intra-alveolar haemorrhages, inter-alveolar haemorrhages and interstitial pneumonitis were observed in lungs among cases died within 24 hours but it was more pronounced after 3 to 7 days of survival period. Focal haemorrhage, infarction, periportal necrosis were seen in liver among cases when percentage of burns is >40 % TBSA. The necrosis and changes in sinusoids of liver which were seen decreased as the survival period increases. Cloudy degeneration, tubular casts in renal tubules of kidneys were common findings in cases with any duration of survival. Tubular necrosis was most common finding in cases with <40 percent of burns followed by acute pyelonephritis and were more pronounced as the percentage TBSA increases. Tubular casts and cloudy degeneration were seen in kidneys, nearly at any percentage of burn. The most common findings in brain were generalized edema 26% cases, followed by vacuolar degeneration in 20% cases. These changes were less marked before 24 hours of survival period and found more pronounced with increase in survival period. Changes in brain seen below 60% TBSA were less marked and found more as the percentage TBSA involved increases. Most common histopathological finding in cardiac tissue were interstitial edema, focal pallor were found at all stages of survival period. Other changes were less marked before 3-7 days of survival period. In heart, changes were found more pronounced with increase in survival period. More pronounced changes in heart observed as there was increase in percentage of burn, particularly at TSBA 81-100%.

Hence sincere attempt is made so that such data would be helpful, not only for autopsy surgeons or pathologists, but also to the treating doctor in deciding line of management for physicians and surgeons to prevent further destruction of the tissue after burn took place.

Recommendations:

In this study, it is observed that histopathological changes in Lungs, liver, kidneys, brain and heart are more marked as the survival period increases. Histopathological changes are more pronounces as the percentage of burns increases. Surgeon or any treating doctor should consider this pattern of histopathological changes while availing the treatment. Treating doctor can prevent the further destruction or injuries to the vital organs after burn by modifying the treatment protocol by keeping in mind the trend of histopathological changes found in this study.

Ethical clearance:

Yes, ethical clearance is obtained from the Institutional Ethical Committee.

Conflict of interest : None.

Source of Funding: Nil.

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ORIGINAL ARTICLE

Estimation of Age of the Person from Progression of Closure of Sagittal Suture as Assessed by Computed Tomography

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Abstract :

When an individual has surpassed the growth phase of life, fewer parameters are left for estimation of age. One such parameter is cranial sutures ossification. This study was conducted to find the feasibility of age estimation from sagittal suture using cross-sectional multidetector computed tomography. This study was done on live patients of known age who presented for computed tomography indicated for other conditions such as headache, epilepsy, etc. The sagittal suture was reconstructed and divided into 4 segments of equal length. A block of 15 mm was randomly chosen from each segment and fifteen cross-sectional images at 1 mm interval were viewed in the coronal plane to assign a stage value (0-6) as defined by Harth et al. Mean scores of these stage values and their correlation coefficients were calculated for the age of the individuals. We found a significant correlation of sagittal suture ossification with the age of the individual. Although our study has yielded wide prediction intervals which preclude its application in forensic casework, still this method can be used in conjunction with other methods of age estimation of adults.

Keywords : Sagittal suture; Cranial sutures; Computed tomography; Age estimation; Forensic anthropology.

Introduction :

Identification is an integral part of the forensic practice in creating a scientific profile of an individual including parameters like race, age, sex, and others. Estimation of age is a useful exercise for the criminal as well as the civil justice system. Here, the chronological age (number of years lived from birth) of the individual is calculated rather than the biological age (degree of senescence). In the younger age group, the ongoing growth provides many parameters like teeth, ossification centers, and epiphyseal union. These parameters are used in combination to determine the age of the individual with fair accuracy.[1] Whereas, age estimation in adults is rendered one of the most important and difficult tasks in Forensic medicine.[2]

As pointed out by Iscan, "*nearly every bone contains an age marker, but it is important that we know where to look for, how to recognize and interpret them*".[3] Extensive research is being done to find new methods of age estimation in adults including evaluation of cranial suture closure, dentition, sternal end of ribs, symphysis pubis and the auricular surface of ilium using different techniques.[4,5,6] Cranial suture ossification as an age marker has been and still is a controversial phenomenon. Some authors suggest it should be included in the estimation of age (Acsadi and Nemeskeri[7], Meind[l] and Lovejoy[8]) while others (Singer[9], Masset[10,] and Hershkovitz[11]) deny any age correlation. Different methods of assessment for cranial suture ossification ranging from a naked eye examination, radiological methods, laser methods, etc. have been employed by researchers across the globe.[2,7,8,12] Advancement in radiology is not limited to non-invasive examination of the human body but its availability even in remote areas has been a significant development.

Computed tomography is a radiological imaging modality that involves mathematical reconstruction of cross-sectional images of a body part by a computer to create a 3-dimensional image.[13] Various studies have been conducted on cranial sutures using computed tomography and they have shown promising results.[2,14,15] Sagittal suture can be easily reconstructed on computed tomography and has shown a significant correlation with the age of the individual.[2] The present study was conducted to test the association of sagittal suture ossification with age in the north Indian population.

The aims and objectives of the study were:

1) To study the chronology and pattern of obliteration of sagittal suture.
2) To detect bisexual variations in sagittal suture closure, if any.
3) To specify the relationship between progression of sagittal suture obliteration and age of the subject.
4) To derive a formula to calculate the age of the individual from sagittal suture ossification by using the data collected.

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Materials and Methods :

This study was conducted at the department of radiology, Govind Ballabh Pant hospital and department of Forensic Medicine, Maulana Azad Medical College between January, 2014 to March, 2015. It comprised 244 cases (121 males and 123 females). Sample size calculation: Considering a coefficient of correlation of 0.79 between age and average stage of ossification,[2] to study a difference of 10% on either side, we require a sample of 12 cases for each age group at $\alpha = 5\%$. Since we are studying 5 age groups, therefore we require 60 cases for age-related correlations. To obtain the bisexual differences at r (men) = 0.71 and r (women) = 0.85 and $\alpha = 5\%$ and Power = 80%,[2] we need a sample of 120 cases for each sex, that is, 240 in total.

The study population included patients presenting for computed tomography of the head for conditions such as headache, epilepsy etc. All cases above 18 years with valid documentary proof of age were included in the study and the following exclusion criteria were applied:

1) Fractured skull or any neurosurgical intervention.
2) Diseased/deformed skull.
3) Systemic Diseases likely to have affected ossification (tuberculosis, tumors, etc.)
4) Conditions associated with secondary craniosynostosis (i.e. early closure of cranial sutures) such as hyperthyroidism, thalassemia, hematologic and metabolic disorders.[16]

Age, sex, and relevant history were noted before CT scan of the head with scanning protocol as tube voltage of 125 kV, tube current of 280 mA on a 16 slice CT scan with collimation of 1 mm. The routine technique was used to reconstruct the 3-dimensional images of the sagittal suture and they were viewed in the coronal plane at a window width of 1,600 HU and window level of 1,000 HU. Sequential images from the sagittal suture were divided into four segments of equal length. Any segment of wormian bone was excluded and not examined. A 15-mm block was randomly chosen from each segment and visual assessment for each image was done by two assessors. The images were assigned a stage value based on seven stages of ossification as defined by Harth et al (Stage value: 0-6, depicted in Figure 1(a)).[16] Any obliteration pattern deviating from the ossification stages described by Harth et al (as illustrated in Figure 1(b).) was excluded from assessment and the next image was studied.

For each segment, three representative scores were calculated based on frequency, average and maximum value of the observed stage values (0-6). In the "Frequency method," the representative score was the stage value with the most frequent occurrence amongst observed stage values for the respective suture segment (as Mode_1, _2, _3 & _4 respectively). In the "Average method," the representative score was the mean of observed stage values from respective suture segments (as Mean _1, _2, _3, and _4 respectively) and in the "Maximum method," the representative score was the highest stage value amongst observed stage values from respective suture segments (as Max 1, 2, 3, and 4).

Ethics and Consent: This study was approved by Institutional Ethics Committee, Maulana Azad Medical College, New Delhi. Written informed consent was taken from all the study participants for study participation and dissemination of the case findings.

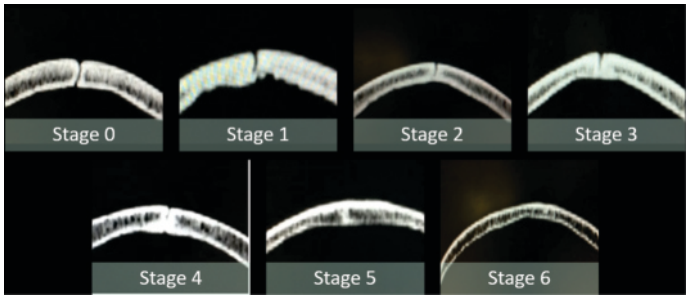

Figure 1 (a): Different stages of ossification as per Harth et al. Stage 0: No ossification observed. Completely open suture. **Stage 1:** Inner bone cortex beginning to close, ossification < 10%. **Stage 2:** Inner bone cortex closed. Stage 3: Less than half of bone cortex (<50%) closed. **Stage 4:** More than half of bone cortex (>50%) closed. **Stage 5:** Completely closed suture with a visible relic of ossification process. **Stage 6:** Completely closed suture, with no relic of ossification visible.

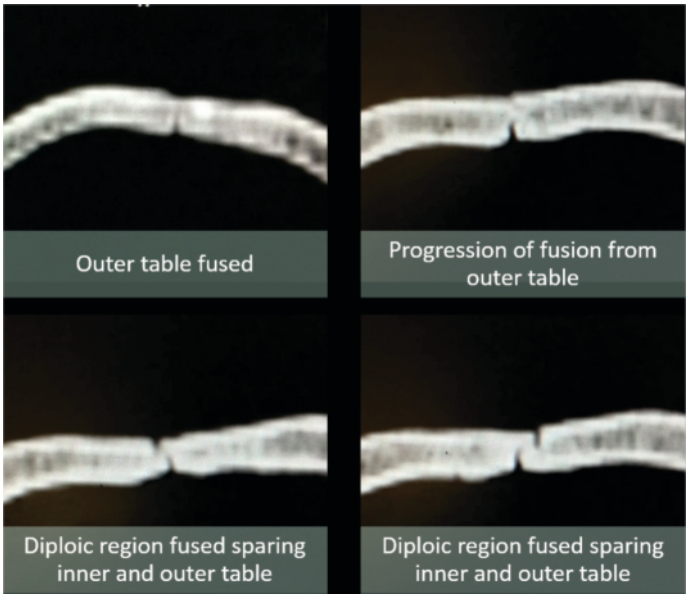

Figure 1 (b): Deviation from general pattern of closure.

Each segment was assigned three scores (e.g. Mean_1, Mode_1, Max_1 for 1st segment) as per different methods and the mean value of four segments was calculated to be the representative score of the whole suture. Three scores calculated from one sagittal suture were designated as Mode_Total, Mean_Total, and Max_Total. These scores were used for further statistical calculations.

Results :

The study comprised 244 individuals, 123 females and 121 males representing 50.4 % and 49.6% of the sample population

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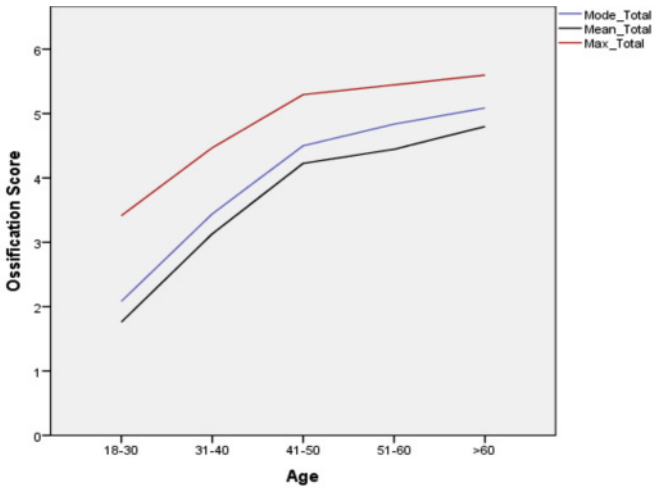

Figure 2: Plot of ossification score versus Age Groups

Table 1 (a): Pearson's correlation coefficient of age with ossification scores

	Mode_Total	Mean_Total	Max_Total
Age	.698	.711	.649
Significance (2-tailed)	.000	.000	.000
Number of subjects	244	244	244

Table 1 (b): Pearson's correlation coefficient of age with ossification scores with individual scores obtained from segments 1-4.

		Mean _1	Mean_2	Mean_3	Mean_4	Mean_Total
AGE	Pearson Correlation	.665	.700	.679	.579	.711
	Sig. (2-tailed)	.000	.000	.000	.000	.000

Table 2: Regression analysis for calculation of coefficients

	Number of subjects	Regression Formula	R^2	P value	95 % Prediction range
Total	244	y = 19.536 + 6.233x	0.506	<0.001	$\pm$20.466

respectively. The mean age of male subjects was 38 years (age range 18-70 years) and the mean age of females was 40 years (age range 18-75 years).

The study population was divided into five age cohorts as 18-30, 31-40, 41-50, 51-60, and more than 60; to study the pattern of closure with progressing age. The scores of ossification for respective age cohorts were plotted on a line graph which is represented in Figure 2.

Pearson product-moment correlation coefficients are calculated for ossification scores obtained by average, frequency, and maximum methods separately. The correlation is strong when the value of Pearson Correlation is more than 0.5. The correlation coefficients calculated between age and ossification scores from Average (Mean), Frequency (Mode) and Maximum (Max) were 0.711, 0.698, and 0.649 respectively. Statistical significance test of these correlation coefficients across the three methods found that ossification scores had a significant correlation with the age

Table 3 (a). Minimum and Maximum age of individuals for 06 intervals of ossification score (Mean_Total)

Mean Ossification Score	Total study population			
	N	Mean Age	Minimum Age	Maximum Age
< 1	33	25	18	37
1 - 1.99	40	27	18	43
2 - 2.99	35	34	19	60
3 - 3.99	43	40	23	65
4 - 4.99	58	51	30	71
5 – 6	35	52	32	75

of the individual ($p < 0.05$).

To test the influence of sex on sagittal suture closure, the Levene test was used which revealed that variances in the mean suture stages were in homogenous. The null hypothesis testing by the Welch test and Mann Whitney U test found that there was no significant difference between the groups based on sex. The obtained p-value of 0.977, 0.997, and 0.654 for Mode_Total, Mean_Total, and Max_Total respectively highlighted no statistical difference in ossification of males and females sagittal sutures.

To formulate a relationship between the age and ossification score of an individual, a simple linear regression analysis was done with 'ossification score' as the independent variable and 'age' as a dependent variable. The regression equation derived was: $y = 19.536 + 6.233x$ (where y represents the age of the individual and x represents the ossification score obtained by the Average method) with a statistical significance level of $p<0.05$ and prediction range of $\pm$20.466 (Confidence interval of 95%).

Table 3(a) shows the age ranges for Mean ossification score divided into 6 class intervals (0–0.99; 1–1.99; 2–2.99; 3–3.99; 4–4.99; 5–6) for the whole study population. Table 3 (b) shows the similar data divided into males and females population separately.

The correlation coefficients were calculated separately after the study population was divided into two groups with a cut-off age of 50 years, as depicted in Table 4. It is observed that sagittal suture ossification score shows statistically significant association with age of individual up to 50 years of age but declines to insignificant level after the age of 50 years is crossed.

Discussion:

As per literature, cranial sutures have shown significant results for the estimation of age, but sagittal suture was chosen as it is the only end to end type suture in calvaria. This prevents pseudo-closure and its location in the midline neutralizes the effects of biomechanical influences.[11] Also, Harth et al reported that of all the segments, the individual analysis gave the best results from sagittal sutures.[16] In addition, the non-invasive nature of CT for ossification assessment makes it a useful tool for its application in living subjects. The data were collected from routine cases

Table 3 (b): Minimum and maximum age of male and female population for 06 intervals of ossification score (Mean_Total)

Mean Ossification	Female Sex				Male Sex			
Score	N	Mean Age	Mini-mum Age	Maxi-mum Age	N	Mean Age	Mini-mum Age	Maxi-mum Age
<1	19	27	18	37	14	24	19	36
1 - 1.99	20	28	18	42	20	27	20	43
2 - 2.99	16	37	22	60	19	32	19	50
3 - 3.99	19	39	23	65	24	41	27	63
4 - 4.99	28	51	30	71	30	50	30	70
5 - 6	21	55	34	75	14	47	32	63

presenting for other indications including seizure disorder, headache, etc. Considerably, the body position and overall clarity of images are likely to vary for each scan but the promising results obtained in our study demonstrate a real-life application of this technique.

Pattern of closure of sagittal suture

Observation of suture closing pattern on reconstructed images on CT, it was found that suture closure occurs from endocranial to ectocranial side which is at par with the observations of Todd and Lyon,[17] Sahni et al[18] and Khandare.[14] The ossification scores obtained from the first segment of the sagittal suture were found to be the lowest amongst the four segments for all age groups and assessment methods. Thus, it can be inferred that sagittal suture ossification occurs slowest in the first segment in comparison to the other segments. This finding agrees with the report of Khandare et al.[14]

Table 1(b) depicts that age correlation was strongest when the ossification score of complete suture (Mean_Total) was used as a variable, in comparison to the ossification score of an individual suture segment. It implies that the whole suture ossification score is a better representative of age than any individual suture segment.

Age estimation:

The sutures of the skull vault commence to be obliterated between the ages of 30 and 35 years, initially on the inner surface and thereafter on the outer surface.[19,20] Sagittal suture starts fusing in between 25-30 years of age and complete closure occurs at the age of 61-65 years.[14] As per Aggarwal A, sagittal suture ossification commences at 25 years, closes halfway by 30 years, and terminates at 40 years of age.[21–23] Still cranial sutures are not considered as reliable evidence for skeletal age identification.[19]

In the present study using multi-detector CT, it was found that sagittal suture ossification score is positively correlated with age of the individual. This finding is consistent with reports of Kirk,[12] Chiba[2] and Harth[16] but in contradiction to those of Stewart,[24] Singer,[9] Powers,[25] Obert[26] and Sahni.[18] Stewart concluded on uselessness of sagittal suture based on observation in 20 archaeological Eskimos specimen, which cannot be generalized.[24] Singer pinpoints his results based on data from his study on 11 individual with retarded and accelerated suture

Table. 4: Pearson correlation of ossification score with study population divided into age groups ≤50 years and >50 years

Cut off age limit	Age group	Number of individuals	Pearson correlation	Sig.
50 years	<50	189	0.673	0.000
	>50	55	0.161	0.239

closure while not providing the data for remaining 419 crania studied.[12] Obert et al[26] concluded that suture closure does not correlate to the aging process and is not useful in age estimation. Although software-based analysis of sagittal suture, employed by Obert et al[26] was accurate but the classification used to grade the cranial sutures has been questioned. The software estimated the sagittal suture in terms of whether it was open or closed. Similar methodological drawback was seen with other reasearchers.[18] Looking at the sutural ossification as a process rather than event, Harth et al employed a different method to assess the closure degree of suture by using a multistep approach. We have employed the similar technique for assessment of sagittal sutures in Indian population and it has yielded positive results. Additionally, other researchers have obtained positive results by assessing the cranial suture with a multistep approach.[14] Methodological differences for cranial suture assessment employed by researchers seems to be a plausible explanation with regard to contrasting results.

One limitation pertaining to the suture scoring scale was observed that suture closure is considered to be a constant progression from the inner table to external table. Although, this pattern was noted to be the general trend but deviation from this pattern was noted in few random slices where obliteration at outer or diploic regions was present while inner table remained open, as illustrated in figure 1 (b). These regions could not be scored and were excluded. Similar findings were observed by Nikolova et al and they have assessed the sagittal suture along the three bone layers on CT scan.[27]

The data shown in table 3 (a) and 3 (b) can be helpful for use as a reference guide for age estimation in a forensic investigation as a suture with average score of 6 from 18-37 years age range is a negative match, and suture with average score of 0 - 0.5 for age range 37-75 years is a negative match. A general trend is observed that a progressive rise in the mean suture stage is also accompanied by a higher average age for both men and women. This finding is in conjuction with that reported by Harth 2009.[15] Conversely in males, mean and maximum ages for suture stage 5 - 6 were found to be lesser than those for suture stage 4 - 4.99 which is seen to be contrary to general trend observed for rest of the population. This phenomenon could be a manifestation of lower age range of male population under study and also lower number of individuals with suture ossification scores between 5 and 6.

After applying linear regression, we have found a 95% prediction interval of ± 20.466 years. This provides a better but fairly large prediction range of 20 years on either side of estimated age of the individual. Chiba et al[2] reported a prediction interval of ± 31.42 years for combined sample, ± 33.55 years for males and ± 29.56 years for females. Harth et al[16] reported a prediction interval of ±

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31.1 years after estimating cranial sutures on flat panel CT. Additionally Harth et al applied extrema method to decrease the prediction range of ossification score and hence strengthen this method for its capability to estimate the age of person. They suggested that this interval can be decreased up to $\pm$ 10 years by use of the extrema and expanding the sample size.[16] Comparable range of results has been reported by Perizonius[28] and Meindl and Lovejoy.[8] Dorandeu et al devised an age prediction formula and found the prediction range of 18.07–69.62 years.[29] Schmitt and Tamska, after examining cranial sutures macroscopically found a 95% confidence interval of ± 32 years for the ectocranial sutures, and of ± 25 years for the endocranial sutures.[30] Boyd reported that young individuals (<40 years) and old individuals (>60 years) could be clearly distinguished from the middle-aged individuals.[31] These differences in prediction range can be attributed to variety of reasons such as: variations in population characteristics; lower age range in the study population (18 to 75 in present study). Estimation of such wide prediction interval precludes its practical application for estimation of age at this stage, but still it has potential for rough estimation of age of skeleton especially when skull is the only remain.

Figure 2 shows a sharp and steep rise in the ossification scores up till the age group of 41-50 years but takes a more horizontal course afterward. This can be interpreted that sagittal suture ossifies fast up to the age of 50 years after which the ossification process slows down. Nawrocki observed that correlation between summed suture closure and age at death, while significant for individuals below the age of 50, drops to insignificant when examining just those individual older than 50.[32] Similar findings were noted by Perizonius in age group of 20-49 years (selec young).[28] Similar observation was made by Lynnerup and Jacobson that young adults below the age of 40 years display an age related development of cranial sutures but that it is impossible to arrive at any precise age determinations for older adults. In the present study that sagittal suture shows positive correlation with the age upto 50 years after which the correlation becomes statistically insignificant.

Chiba et al[2] used the multi-detector CT, while Harth et al[15] reported the similar findings on flat panel CT. Flat panel CT is thought to have a higher spatial resolution, leading to a more exact representation especially of the bony structures.[33] But Chiba et al concluded that age estimation using multi-detector CT was not only possible but also generates results equivalent to macroscopic or flat panel CT assessment in terms of prediction interval assessment.[2] This study conducted using multidetector CT is in agreement with the findings of Chiba et al.

Influence of Sex:

The influence of sex on cranial suture closure is also under question as reports from various researchers show controversial results. Some researchers like Sabini and Elkowitz,[34] Meindl and Lovejoy,[8] Obert[26] and Harth[16] have observed no significant difference in cranial suture ossification of male and female populations. Whereas, studies by Hershkovitz,[11] Sahni,[18] Chiba,[2] Kumar[35] and Verma[36] noted significant sexual difference in the closure of cranial suture. Earlier closure in males was reported by Verma[36] and Sahni,[18] while Kumar[35] and Chiba[2] found earlier closure in female study population. In our study, sagittal suture ossification was found to be independent of sex of the individual.

Conclusion :

Our study seems to confirm that sagittal suture ossification is a potential tool for estimation of age in adults but the large prediction interval obtained in the study precludes its application as an individual method for identifying the age of the individual. This method can be used as a valuable asset when it is combined with other methods of age estimation.

We recommend that this study be carried out more extensively on larger samples in different populations to arrive at a final conclusion regarding the validity of this method in the estimation of age.

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CASE REPORT

Incidental Finding of Systemic Granulomatous Disease in a Case of Sudden Cardiac Death: A Rare Autopsy Case Report

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Abstract :

Forensic experts very commonly encounter cases of sudden deaths during their practice, of which, majority of them are due to cardiac conditions. Sudden cardiac deaths can either be related to cardiac arrest following electrical abnormalities or due to coronary artery disease or any other pathology of heart. Here, we present a rare case of accidentally detected systemic granulomatous disease during histo-pathological examination of tissues collected at the time of post-mortem examination where the cause of death is coronary artery thrombosis.

Keywords : Coronary artery thrombosis, systemic granulomatous disease, coronary artery disease, sudden death, sudden cardiac death.

Introduction :

Granulomatous disorders comprise a large family sharing the histological denominator of granuloma formation. They are classified into infections, vasculitis, immunological aberration, leucocyte oxidase deficiency, hypersensitivity, chemicals, and neoplasia.[1] The term granuloma is used to describe the aggregation of these modified macrophages into nodular aggregates. Lymphocytes and plasma cells are also seen, usually at the periphery of granulomas.[2] Systemic inflammatory diseases represent a large group of rare diseases that may involve all organs.[3] Granuloma formation, most frequently in the respiratory, gastrointestinal and genitourinary systems is a common complication of chronic granulomatous disease and can be seen even before diagnosis.[4]

Caseation refers to the white, cheesy gross appearance of tissue necrosis most commonly seen in foci of tuberculous infection. Caseation has been used interchangeably with the microscopic description of necrosis and, as described above, is absent in sarcoidosis.[2] Cardiac involvement presents either as: (I) pericarditis; (ii) myocarditis or myocardial fibrosis due to myositis or vasculitis with rhythm and conduction disturbances and diastolic or systolic heart failure; (iii) coronaritis with ischaemic heart disease; (iv) endocardial involvement with valvular disease and formation of thrombi; (v) pulmonary hypertension secondary to concomitant lung disease or recurrent lung embolism; (vi) unexplained arterial thrombosis; (vii) syncope; and (viii) (malignant) arterial hypertension.[3]

Case Presentation :

A 28 year old male presented to an emergency department of tertiary care hospital with history of severe chest pain and profuse sweating for past four hours. While shifting the patient to bed suddenly went into cardiac arrest. Immediately cardio pulmonary resuscitation was started as per advanced cardiac Life Support guidelines. The patient could not be revived. There was no history of trauma to the chest or abdomen. The body was sent to Mortuary for post mortem examination. On external examination, the deceased was thin built and there was no injury evident over the body. On internal examination, both sides of the chest cavity showed pleural adhesions and both lungs were adherent to posterior surface of chest wall. Right side of the chest cavity contained 150 ml of straw colored fluid and left side of chest cavity contains 250 ml of straw colored fluid. The cut section examination of lungs revealed oozing of frothy fluid. The weight of heart was 330 grams; the epicardial surface was smooth and glistening with moderate amount of epicardial fat. The great arteries were in their normal position and in relation with others. Epicardial course of coronary arteries was normal. Thickness of left ventricular wall was 2.5 cm and right ventricular wall thickness was 1.0 cm. The inter-arterial septum was intact and atrio-ventricular connections were present. The chambers of heart contained blood.

Histo-pathological findings of lungs

The findings were suggestive of pulmonary edema. The section of left lung showed few epithelioid like cells, multi nucleated giant cells and lymphocytes. Intra-alveolar macrophages and congestion were also noted. Focal anthracopoietic pigmentation was seen. All the findings favored a chronic granulomatous inflammation (shown in Fig. 1,2).

Histo-pathological findings of heart

Left and right ventricular walls and apex show focal hypertrophy of myocytes. Foci of ischemia were also seen. Inter-ventricular septum showed focal hypertrophied myocytes. Right coronary artery, left coronary artery and left circumflex artery showed changes of type II atherosclerosis with minimal intracellular lipid. A section showed lesion in right coronary artery with

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thrombus attached to the wall in form of alternating light and dark line (Line of Zahn) as well as entrapped white blood cells, red cells and aggregates of platelets. There was lymphoplasmocytic inflammation with few macrophages and hemosiderin pigment.

Histo-pathological findings of kidneys: Changes were suggestive of chronic pyelonephritis with granulomatous inflammation (shown in Fig.3 , 4).

The cause of death in this case is ischemia due to coronary artery thrombosis in a case of systemic granulomatous disease.

Discussion:

A number of new reports have given information on adult patients with chronic granulomatous disease (CGD). Adult patients fall into three categories: those diagnosed as children and surviving to adulthood, those who are symptomatic in childhood but are diagnosed only as adults and those with mild disease who present for the first time as adults.[5]

Granulomatous inflammation is a histologic pattern of tissue reaction which appears following cell injury. Granulomatous inflammation is caused by a variety of conditions including infection, autoimmune, toxic, allergic, drug, and neoplastic conditions. The tissue reaction pattern narrows the pathologic and clinical differential diagnosis and subsequent clinical management. Common reaction patterns include necrotizing granulomas, non necrotizing granulomas, suppurative granulomas, diffuse granulomatous inflammation, and foreign body giant cell reaction.[6]

In this case, histo-pathological examination of lung shows a well-formed caseating granuloma in lung parenchyma suggestive of mycobacterial etiology. Hence, Ziehl–Neelsen stain was used to detect acid-fast bacillus but it was negative even after detailed evaluation of the granulomas at various depths of the tissue blocks. Microbiological culture was not possible due to accidental detection of CGD during histo-pathological examination.

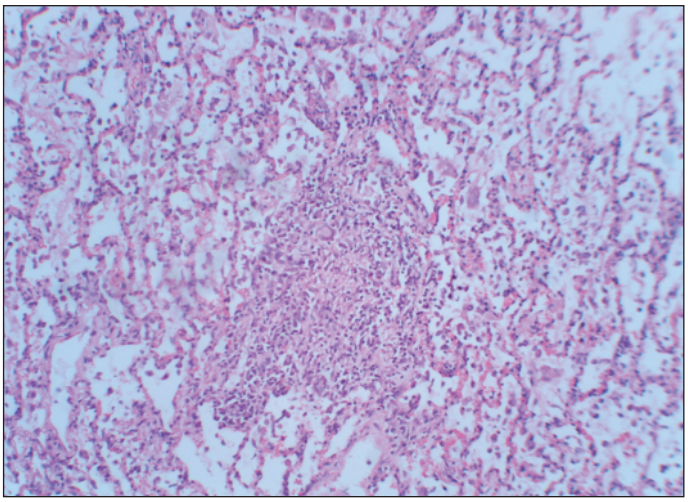

Fig. 1. Microphotograph showing a well-formed caseating granuloma in lung parenchyma (100x, H& E stain)

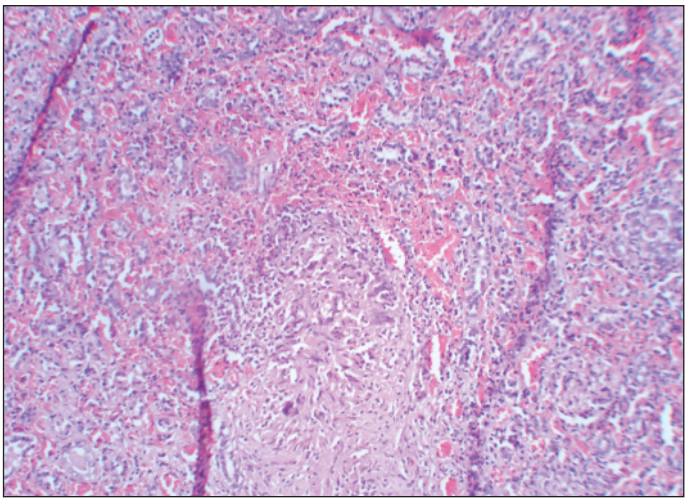

Fig. 3. Microphotograph showing a single ill-defined epithelioid granuloma in renal parenchyma (100x, H & E Stain)

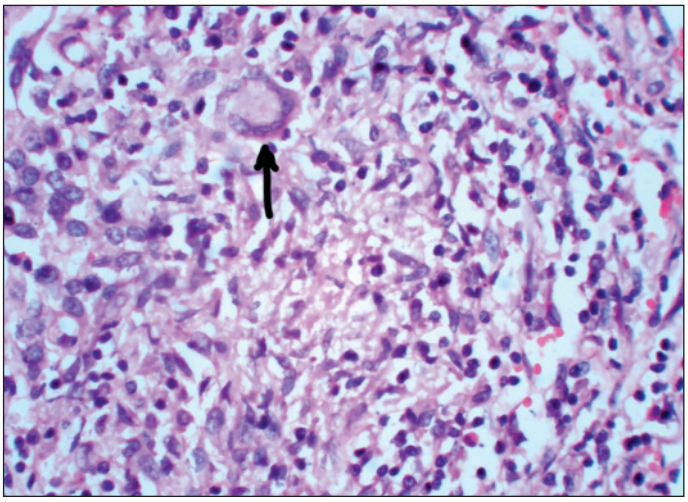

Fig. 2. Microphotograph showing epithelioid cells with Langhan's type of giant cell indicated by black arrow (400x , H& E stain)

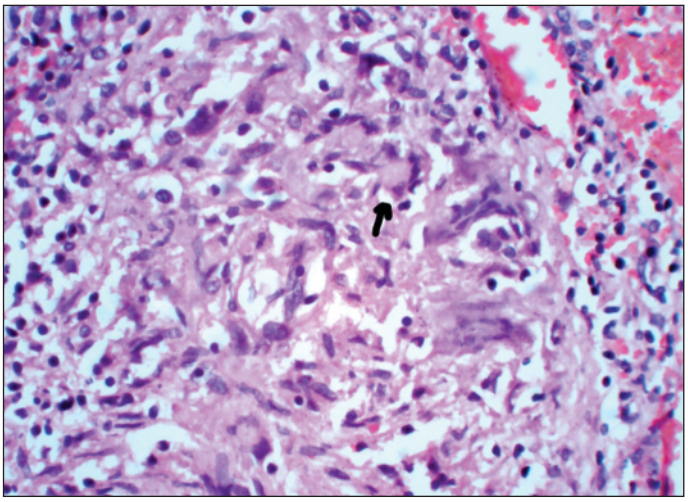

Fig. 4. Microphotograph showing collection of plump epithelioid cell sand Langhan's type giant cell indicated by black arrow (400X, H& E stain).

Moreover, many studies show that there can be negative results in stains of cases of mycobacterium tuberculosis as suspected etiologic agent.

Conclusion :

Cases have been reported related to coronary artery disease in patients with systemic granulomatous disease. Very few cases have been published where coronary artery thrombosis is the cause of death in case of systemic granulomatous disease. Therefore, it is advisable to medical practitioners to request the patients with any kind of systemic granulomatous disease to undergo thorough cardio-vascular evaluation at regular intervals.

Limitations :

Due to lack of history, cost related issues as well as unavailability of certain facilities, exact type of systemic granulomatous disease could not be diagnosed.

Conflict of Interest Statement :

The authors have no conflicts of interest to declare.

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CASE REPORT

Dilated Phase of Hypertrophic Cardiomyopathy: A Postmortem Diagnosis

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Abstract :

Cardiac pathology is one of the leading causes for global morbidity and mortality. Coronary heart disease is the commonest causes of sudden cardiac death throughout the world. Also, hypertrophic and dilated cardiomyopathies were recognized independently as the causes of sudden cardiac death in adults and elderly persons. However, progression of hypertrophic cardiomyopathy to a dilated cardiomyopathy resulting in death is less commonly reported. Herein, we discuss a case of hypertrophic cardiomyopathy with features of dilatation of the cardiac chambers in an adult male which was diagnosed during the postmortem examination.

Keywords : Sudden death; Sudden cardiac death; Myocarditis; Dilated Cardiomyopathy.

Introduction :

Sudden cardiac death is an unexpected death due to cardiac causes within an hour of onset of terminal symptoms.[1] The most common cause of sudden cardiac death is coronary heart disease followed by cardiomyopathies, left ventricular hypertrophy, valvular heart disease, congenital heart disease, primary electrophysiological abnormalities such as congenital long-QT syndrome, Wolff-Parkinson-White syndrome, ventricular tachycardias, idiopathic ventricular fibrillation, arrhythmogenic ventricular dysplasia.[1-3]

Cardiomyopathy refers to diseases of heart muscles and is the second commonest cause of sudden cardiac death. The different types of cardiomyopathies include hypertrophic cardiomyopathy (HCM), dilated cardiomyopathy (DCM), restrictive cardiomyopathy, right ventricular cardiomyopathy, inflammatory cardiomyopathy and non-classified cardiomyopathy.[4] Hypertrophic cardiomyopathy (HCM) is characterized by thickening of the myocardium especially the ventricles. The annual incidence of sudden cardiac death due to HCM is 2% to 4% in adults and 4% to 6% in children and adolescents. Dilated cardiomyopathy (DCM) is characterized by dilatation of the left ventricle with impaired systolic function. The annual incidence of sudden cardiac death due to idiopathic DCM ranges from 10% to 50% in adults.[1] Inflammatory cardiomyopathy refers to myocarditis with associated cardiac dysfunction. About 8.6% to 12% of death in young adults is due to sudden cardiac death caused by myocarditis, and 9% cases of myocarditis progress to dilated cardiomyopathy.[5,6]

Herein, we report a case of HCM with features of DCM and myocarditis which was detected in the postmortem examination.

Case Presentation :

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A 35-year-old male while travelling in a car developed an acute pain in the chest and rushed to the nearby hospital. However, he died on arrival at the hospital and did not respond to resuscitation measures. As per the legal protocol of the State, the deceased body was subjected to medicolegal autopsy to find out the cause of death. Investigating officer revealed that the deceased was on a official visit from the neighboring district. Further interaction with the friend of the deceased who accompanied him to the hospital revealed that the deceased was a known heart patient and was on treatment. But, he was not knowing the details of the disease and medication.

At autopsy, the external examination revealed a body of a middle-aged obese male with congestion of face, conjunctiva and lips. There were no external injuries on the body. Internal examination showed congested brain and weighed 1400 gm. Right and left lungs weighed 840 gm and 680 gm respectively, and the cut sections showed oozing of frothy fluid. The liver weighed 2800 gm and cut section showed congestion and yellowish discolouration. Spleen and kidneys were congested, and pancreas was unremarkable. The heart measured 15 cm x 14 cm x 7 cm and weighed 800 gm. The heart was dissected by the short axis method. The endocardial surfaces of all the chambers appeared normal. The left ventricular chamber was dilated and measured 7 cm and the left ventricular free wall measured 3 cm in thickness, consistent with hypertrophy (Fig. 1). These features were suggestive of dilated cardiomyopathy. The coronary arteries were patent. Aorta showed mild atherosclerotic changes. All other organs were within normal limits.

Tissue sections were submitted for histopathological examination. Microscopic examination of the sections from both lungs showed pink proteinaceous fluid in the alveoli and hemosiderin laden macrophages along with congested capillaries, suggestive of pulmonary edema and chronic passive congestion of the lungs. Sections from the liver showed microvesicular fatty change, congestion and mild periportal lymphocytic infiltration. Sections from the spleen showed congestion along with hemosiderin laden macrophages. Sections from both kidneys showed congested capillaries and degenerative changes in the tubular lining cells. Sections from the heart showed enlarged cardiac muscle fibres with large nuclei suggestive of

myocardial hypertrophy. Some of the myocardial fibres were disrupted. Foci of lymphocytes infiltrating the connective tissue were seen in several areas (Fig. 2 & 3). Intervening connective tissue was significantly increased with thick fibrotic bands in areas which was confirmed by Masson's Trichrome stain (Fig.4). These features were suggestive of chronic myocarditis with dilated cardiomyopathy. Sections from the coronary arteries showed patent lumen. The cause of death was opined as heart failure secondary to dilated cardiomyopathy.

Fig. 1. Heart – gross features – Heart is enlarged with thickened ventricular wall indicating cardiomegaly and ventricular hypertrophy.

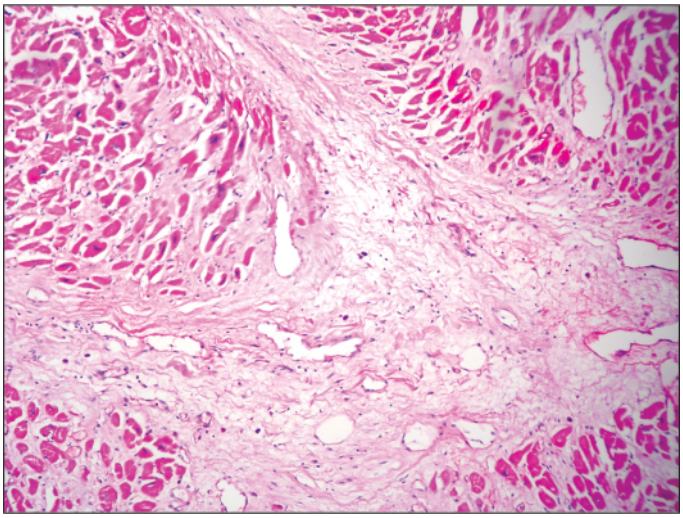

Fig. 2. Left ventricular myocardial tissue shows thick fibrotic bands. Some of the muscle fibres are enlarged in size with large nuclei. Some of the myocardial fibres are disrupted. (H & E stain x100).

Discussion:

Hypertrophic cardiomyopathy (HCM) is characterized by left ventricular hypertrophy with a wide range of clinical manifestations such as syncope, dyspnea, fatigue, chest pain, palpitations, and atrial or ventricular arrhythmias.[7] The mortality of HCM is very low. The risk factors for sudden death in HCM include family history of sudden cardiac death, history of sustained ventricular tachycardia, diverse genotype, recurrent syncope, multiple episodes of non-sustained ventricular tachycardia, and massive left ventricular hypertrophy.[1] In the present case, the patient was a young adult male with known heart disease. During postmortem examination, an enlarged heart weighing three times that of the normal with increased thickness of the left ventricular wall was observed, suggestive of long standing HCM.

Dilated cardiomyopathy (DCM) is characterized by progressive

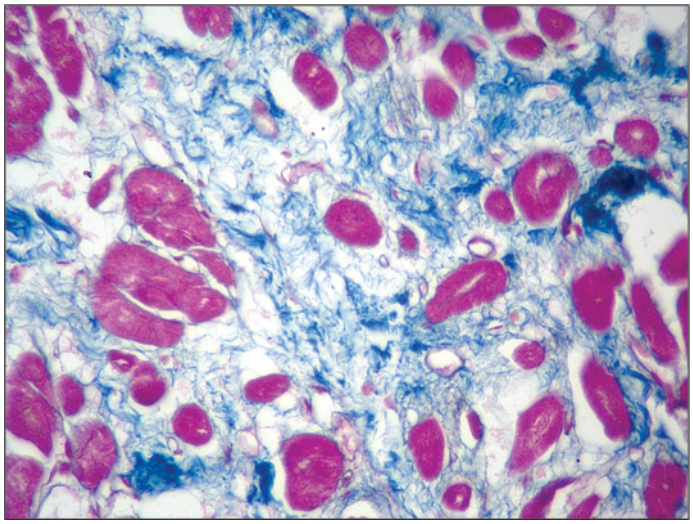

Fig. 3 Left ventricular myocardial tissue shows prominent and widespread interstitial fibrosis (Masson's trichrome stain, ×100).

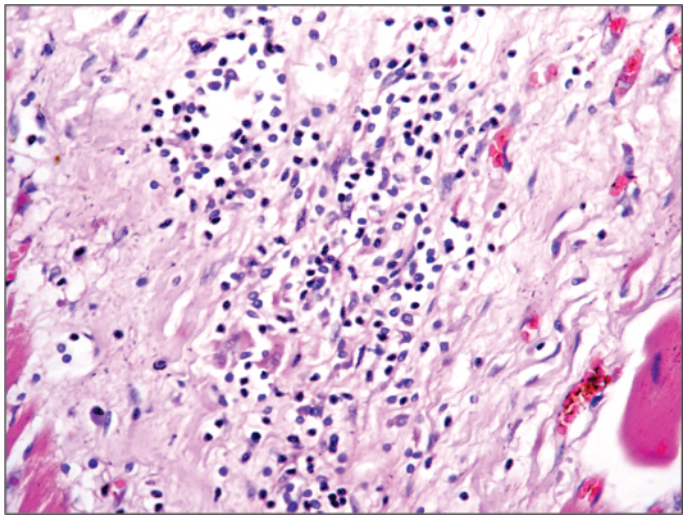

Fig. 4. Histology of left ventricular myocardial tissue shows thick fibrotic bands and intense infiltration with lymphocytes, occasional eosinophil and macrophage suggesting chronic myocarditis. (H & E stain x100).

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cardiac dilatation and contractile (systolic) dysfunction, usually with concomitant hypertrophy. It is also called as congestive cardiomyopathy. The heart is usually enlarged and flabby due to dilatation of all the chambers. Mural thrombi with embolization are common. There are no primary valvular alterations and the coronary arteries are free of significant narrowing. DCM is commonly seen in persons between 20 to 50 years with male preponderance (male to female ratio 2.5:1). The causes of DCM include genetic disease, infection, inflammation, autoimmune diseases, exposure to chemicals/toxins etc.[8] Patients with dilated-phase of HCM (d-HCM) are more symptomatic at the time of diagnosis with increased chances of atrial fibrillation.[9] The morbidity and mortality are high in d-HCM, which is characterized by dilatation of the heart chambers especially left atrial diameter with thinning of the ventricular wall.[7,9] The insidious progression from HCM to typical DCM-like feature related to the chronic progression of necrosis and massive fibrosis, due to severe stenosis of the intramural coronary artery.[10] In the present case, the heart was enlarged and flabby with significant dilatation of the left ventricle chamber along with significant cardiac hypertrophy, whereas all the coronaries were patent.

Inflammatory cardiomyopathy can be idiopathic, autoimmune or due to infection. Viral cardiomyopathy is one of the commonest forms of infectious cardiomyopathy, which is determined by the presence of virus in the dilated heart. If this is accompanied by myocardial inflammation, it is called as inflammatory viral cardiomyopathy. If there are no inflammation (<14 lymphocytes and macrophages/mm^2), it is called as viral cardiomyopathy or viral persistence in DCM.[4] The clinical presentation of myocarditis is very broad ranging from asymptomatic to heart failure. Patients generally present with fatigue, dyspnea, palpitations, precordial pain or fever. Patients may develop dilated cardiomyopathy and death is usually due to progressive cardiac failure or arrhythmias.[11]

Histological changes in DCM are usually non-specific and do not point to any specific etiological factor. Most of the muscle cells will be hypertrophied with enlarged nuclei, whereas some muscle cells will be attenuated and irregular. There may be massive fibrosis, diffuse disarray and severe narrowing of the intramural small arteries and arterioles in septum and wall of the ventricles.[12,13] In the present case, many cardiac muscle fibers were hypertrophic with enlarged nuclei. Some of the muscle fibres were irregular and showed cellular breakdown (Fig. 2). There was a significant interstitial fibrosis which was confirmed by Masson's trichrome staining (Fig. 3). Left ventricular myocardium showed foci of lymphocytic infiltration of connective tissue of the heart along with an occasional eosinophil and macrophage suggestive of myocarditis (Fig. 4). Also, there was patchy fibrosis indicative of healed lesions. In the present case, there was a severe cardiac hypertrophy along with features of dilated cardiomyopathy suggestive of dilated phase of HCM. Also, there was a feature of myocarditis which could be idiopathic or viral origin.

Conflict of interest :

The authors declare that there is no conflict of interest.

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CASE REPORT

Death due to Decapitation in a Motorcycle Accident – A Case Report

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Abstract :

Death due to decapitation is rare in Forensic practice. Though decapitation is usually associated with homicides, in civilians it is more commonly seen in railway suicide. Decapitation in road traffic accidents is very rare, seen in high-speed impacts, and almost always involve unusual circumstances. Here we discuss a case of complete decapitation in a motorcycle accident where the non-helmeted deceased lost control of his motorcycle and hit the divider on the road resulting in decapitation. Correlating the findings at the scene of accident and autopsy was crucial to determine events of the accident and mechanism of the decapitation.

Keywords : Forensic medicine; Decapitation; Road traffic accident; Motorcycle.

Introduction :

Decapitation can be Internal (where the skull separates from the spine due to disruption of ligaments, without any external breech), Complete (where head is completely separated from the body, e.g. In beheadings) or Partial (where head is attached to the body by some neck tissue).[1] Various mechanisms of decapitation injury have been reported in literature, ranging from railway suicides to homicidal beheadings. In civilian population, decapitation is usually found in victims of railway suicides, where they deliberately lie down on the railway tracks to be run over by oncoming train.[2] Beheading was a common form of execution in the Middle East and Europe.[3] It is also common in violent war zones, terrorism and gang wars, where the violent impact of blast injuries and heavy weapons severe the victim's head.[1]In homicides, decapitation is often post-mortem as the victims may be dismembered, and associated with impact of heavy sharp objects or weapons. Decapitation in suicides have been reported in cases of hanging, vehicle assisted suicide using ligature material, and fall from height.[4,5,6,7]Accidental decapitation is seen in industrial accidents,[8] train accidents and in road accidents.

We present a rare case of complete decapitation in a motorcycle accident and discuss the events of the accident and mechanism of the decapitation.

Case Report :

A31-year-old male deceased was brought to the department of Forensic Medicine of Lokmanya Tilak municipal hospital, Mumbai, for post-mortem examination with alleged history of decapitation following road traffic accident while riding on his motorcycle on flyover of eastern express freeway, Mumbai. On perusal of inquest papers, visiting the scene of accident and examination of the motorcycle, it was revealed that the deceased was speeding on the freeway on his motorcycle without wearing helmet, when he lost control of his vehicle. He fell towards the divider and his head hit the vertical metallic beam supporting the divider railing, which decapitated him.

His head was found near the divider, his body lying 45 feet further in the middle of the road in supine position and the motorcycle was 300 ft further away from the body. There were blood splatter and skid marks on the metal sheet divider, and blood splatter on the ground and a light pole. A blood-stained piece of the victim's shirt was stuck to the vertical beam of the divider. The right foot sandal (Foot wear) of the victim was located 7 feet behind the beam and the severed right toe of the victim was 35 feet behind the beam. Shattered parts of the victim's wrist watch were scattered around the scene of accident.

The major damages on the motorcycle were on the right side, suggestive of the motorcycle falling on its right side, with scratches, bent safety guard and broken brake on right side. Blood stains were present on the exhaust muffler and rear suspension system on the right side. On further investigation, it was found that the deceased was allegedly returning home after drinking alcohol with friends.

On external examination, the deceased was averagely built & well nourished. There was a complete decapitation (Figure 1) at the level of atlanto-occipital joint with circumferential skin laceration with irregular edges, showing the transected trachea and other neck structures with blood infiltration present in surrounding tissues. There was dirt and gravel adhered to the surface and tissues (Figure 2). An hour hand of wristwatch of the deceased was stuck on the posterior surface of the transected trachea. There were multiple abrasions on the left side of frontal scalp, left forehead, left eyebrow, chin and right ear lobule, with fractures of nasal and zygomatic bones of both sides. The transected cervical spine was visible as jutting out from the torso.

The first and second vertebrae were fractured and attached to the spine only by few tissues posteriorly. The cervical spine was fractured at the level of C5-C6 intervertebral disc space with posterior displacement of upper part.

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There was a curved linear fracture line present circumferentially on the caput, with sparing of right frontal region. Multiple comminuted fractures were present on anterior, middle, and posterior cranial fossae on base of skull. Crush injury was present on temporal and occipital region, with patchy subarachnoid hemorrhage and contusions on bilateral frontal and occipital regions.

Abrasions were present on both shoulders and on scapular region on upper back and medial aspect of left forearms. A bone-deep laceration was present on medial aspect of right forearm, with compound fracture of underlying ulna and radius. Abrasions were present on both knees, shin of right leg and calf of left leg. There was closed dislocated fracture of left knee. There was degloving injury of right foot. The right great toe was severed at the level of distal phalanx and present beside the body, with fracture dislocation of second toe (Figure 3). All internal organs were intact and pale. Blood was preserved for grouping and chemical analysis

Figure-1 Decapitated head

Figure-2 Lacerated margins with heaping of skin, avulsed trachea jutting out. Dirt adhered to surface.

Figure-3 Amputation of toe with degloving

Figure-4 Erosion on the handle

Figure-5 Torn piece of shirt collar near the site of impact of head with bloodstains

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Discussion:

Complete decapitation is rare in motorcycle accidents. The common mechanism involved is impact of the dynamic head on a static object. Another important mechanism, as noted by Hitosugi et al. and Byard et al is hyperextension of the neck due to a strong facial impact and indirect mechanism of inertia.[9,10] Ausania et al mentioned a similar mechanism (hyperextension and inertia) when reporting the decapitation of an unbelted victim who was partially ejected from a car.[11] Manoj et al described a case of decapitation where the passengers head that was sticking out of the window of a bus hit a passing tempo and was decapitated by a scissor mechanism between the window frame and the truck.[2] Similar case was reported by Rashid et al.[12] Angelino et al. described a case of a pedestrian who was hit by oncoming car, and was decapitated by impact of sharp splintered glass of the top of the windshield as the body moved headlong through it.[13] A case of double decapitation of motorcyclists was reported by Osculati et al. where a plastic cable that had detached from a timber-transporting machine whipped the road and hit the two motorcyclists, and the impact resulted in the complete severing of both riders' heads.[14] There are independently reported cases of vehicle assisted suicides reported by Zhaoand Turk where decapitation was caused by ligature material that tightened when the vehicle was driven.[5,15] In motorcycle accidents, a case report involved a full-face-helmeted victim where the impact of chin strap after violent angular motion of the head caused incomplete decapitation with herniation of thoracic organs.[16]

Atlanto-occipital Dislocation may be caused by different traumatic mechanisms, all having in common the transmission of excessive force to the cranio-cervical junction, leading to widespread ligamentous disruption. Such mechanisms include hyperextension, hyperflexion, lateral flexion, or a combination of these. Hyperextension injuries of the spine are seen mainly in whiplash-like injuries where the moving head is jerked forwards abruptly followed by backward movement. It is seen in high-speed vehicular crashes. Hitosugi et al. described a case of accidental partial decapitation in a motorcyclist where the head was in static position against a hard surface and the body moved backwards due to oncoming vehicular impact in continuum with inertia, causing hyperextension of cervical spine leading to partial decapitation.[9] Dr. Bangal et al described a where the motorcyclist was decapitated when he hit the embankment of freeway bridge while driving at high speed.[17]

In our case, the injury was caused by a combination of hyperextension of the neck and sharp force injury. Detailed study of scene of accident allowed us to recreate the events of accident.

The motorcyclist was driving without a helmet at high speed on the freeway where two-wheeler vehicles were not allowed to ride. He lost his control and leaned towards the divider to the right as was evident from the linear scruff marks on the divider beams and corresponding erosion on the motorcycle on right handle rubber grip and underlying exposed metal frame of the handle on the outer end (Figure 4). As the elbows and feet are the most lateral part of the body of a motorcyclist, his right foot impacted upon the vertical beams of the divider, causing amputation of the right toe and degloving of right foot. The right footwear and part severed toe along with blood stains on the vertical beam were found on the site of accident. Blood stains were found on the motorcycle on exhaust muffler and rear suspension system near the right footrest of the rider. The injury made him lean further instinctively to his side, causing his right forearm to hit against the edge of the horizontal metal beams, causing the laceration and compound fracture. Further ahead, his shirt collar was caught on a vertical beam of the divider, as was evident from the piece of collar of the victim's shirt hanging from the beam (Figure 5), which caused a whiplash-like effect, along with impact of the hyperextended neck on the edge of the horizontal metal beams, as was evident by the fracture of cervical disc between C5 and C6 and posterior displacement of the proximal fragment. The abrasion on right forehead, ear lobule and right side of the neck with lacerated margins suggestive of start of avulsion and heaping of skin on the left posterior aspect of the neck suggesting last point of separation also correlate (see Figure 2). Corresponding blood stains were found on the horizontal beam at the site. The head was thrown further down the road by momentum and was found 45 feet away from the site of impact, with evidence of blood and tissue stains on the ground. The force with which the head hit the ground and rolled over must have caused the facial and cranial fractures. The relative lack of significant under-scalp hematoma suggest that the cranial fractures were post-decapitation. The body was thrown further away, found lying in supine position with hyper-flexed left knee, which caused the dislocation, and grazed abrasions on the posterior surface of upper limbs. The motorcycle which was found further down the road lying on its right side with scruff marks and bent safety guard. The skid marks on the ground were corelated.

Hence in this case, the two mechanisms involved – hyperextension of the neck due to abruption in the linear motion, and sharp force injury to the neck due to high-speed impact on the edges, together caused the unusual complete decapitation.

Conclusion:

Accidental decapitation in road traffic accidents is a rare injury and almost always associated with unusual violent circumstances. The relatives of such victims may be shocked and question the manner of death. Hence, it is important to recreate the events of accident and rule out any other manners of death. This can be done by studying the mechanism of each injury on the body, making good use of police inquest, visiting the site of accident, as well as considering the vehicular damage. Such holistic approach can help in determining why such violent injuries happen in road accidents, why they are rare and how to prevent them in future.

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CASE REPORT

An Atypical Suicidal Cut Throat Injury- Mechanism Uncovered after Injury Interpretation

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Abstract :

Suicide is an intentional act of injuring oneself, irrespective of the outcome. However, there are other forms of suicidal behaviour existing among the people. The year 2020 is a hard time due to COVID19 pandemic as it had created difficulty to many people especially the lower economic class people to meet their daily livelihood. The result is many poor victims committing suicide. The method used for committing suicide vary from region to region. However, cutting one's own throat to end their life is very rarely performed by the victims of suicide. A careful interpretation of the injury is required by the forensic pathologist to conclude the manner of the death in such deaths. Here we report one such case, and the manner is concluded after studying the injuries tediously in summation with the police investigation.

Keywords : Self-inflicted; Cut throat injury; COVID 19 Suicide; Incised wounds.

Introduction :

Suicide is a Latin word and it is a type of deliberate self-harm. It is defined as a human act of self-intentioned and self-inflicted cessation of life. Suicide is an intentional act of injuring oneself, irrespective of the outcome. However, there are other forms of suicidal behaviour existing among the people.[1] WHO reports that there is one suicidal death in 40 seconds all over the world. There is also an increase of suicidal rate by 60% worldwide during the last 50 years. The methods used for committing suicides vary from one region to another. Hanging and poisoning are considered to be the commonest method to execute the act based on the various studies conducted. However, 309 IPC criminalises attempted suicide, the recent provisions of the Mental Health Care acts 2017 says that the person shall not be tried and punished if it is proved that the person is suffering from severe stress. The year 2020 is a hard time due to COVID19 pandemic as it had created difficulty to many people especially the lower economic class people to meet their daily livelihood. The result is many poor victims committing suicide. This particular case is one from such a cluster, where the deceased has died due to cut throat injury. This case report is discussed with a motive to express the novelty of the cut throat injury witnessed during the autopsy at our institute

Case Report :

A middle-aged man who is a daily wage worker at Delhi committed suicide by cutting his own throat at his residence during late night when he went to restroom. He committed suicide due to the fear of COVID19 disease as he is suffering from the cough for past 2 days. The deceased is brought dead to AIIMS, New Delhi and autopsy is requested. At autopsy, a cut throat wound formed by coalesced incised wounds, transverse in placement measuring 15cm x 4.5 cm x airway deep is present at front and sides of neck across midline of which two wounds involved the floor of mouth (Fig 1a). Margins of the wound are clean cut and are complimentary and corresponding to each other. On hyper-extension of neck there are two identifiable tailing towards right (Fig 1b). One tailing is present directed upwards and another is directed downwards (Fig 1c). The severed injury involves anterior neck structures including muscles of front of neck, thyrohyoid membrane and left internal jugular vein (Fig 1d). The underlying hyoid bone and cervical vertebraare intact. No other injuries or hesitation cuts are present over the neck and accessible parts of the deceased like inner aspect of forearm, wrist joint, chest region, groin region etc. Generalised pallor is demonstrated over the conjunctivae, nail beds. The deceased clothes are stained with blood. In view of COVID19 pandemic and also the COVID19 status of the deceased is unknown, minimal autopsy is conducted according to ICMR guidelines.[2] The cause of death is given as hemorrhagic shock due to cut throat injury by sharp edged weapon.

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Discussion:

Cut throat injury done as a result of self-harm is very rare choice as it is a painful and a struggling method.[3,4] The main role of the autopsy surgeon is not only to comment the cause of death but also to suggest the possible manner in which the injury can be caused as it gives a lead to the investigative procedures. We will now discuss the atypical case findings observed one by one and compare with the literature to uncover the mechanism.

In this case, the cut throat wound is horizontally placed with the tailing of the wound towards right. There are no other hesitant cuts found either above or below the cut throat wound, however the wound shows two tailing of wounds as mentioned above. The combination of suicidal cut throat wound without hesitation mark is rarely reported in the literature. Knight and Saukko concludes that the deceased before cutting the neck, tries to give superficial

tentative cuts either in the neck or at the wrist joint. It is also mentioned that the incision starts at a higher level and ends at a lower level maintaining an oblique course.[5] Our case contradicts the findings mentioned by Knight and Saukko.

There is lack of involvement of the carotid artery in this case while the internal jugular vein on the left side is cut at the front. The mechanism of Hyperextended suicidal cut throat as postulated by Taylor, suggest separation of thyroid cartilage and hyoid bone which makes the carotid to hide behind the transverse process of cervical spine. This results in sparing of the carotids as seen in our case which confirms that the deceased has hyperextended. He did not maintain a single posture to complete the act as multiple incised wounds are present on the neck as shown in Fig 1A.[6] On studying the multiple deeper cuts on the left side and the superficial tailing on the right side, the possibility of homicide is ruled out. We also confirmed that the deceased is a right-handed individual. This is clarified to us by the police through their investigation. This finding seen in our case is most commonly observed in cut throat wounds and the same is concluded by Buchade et al in their study.[7]

The cut throat wound is found to involve the Zone II of the neck which is the area between cricoid cartilage and the angle of mandible. This is the largest zone of neck and more accessible to the trachea, internal jugular vein and carotid artery. Moreover, the force used by the deceased to commence an incision will be more which can easily incise the overlying muscle and gains access to the jugular vein. The presence of multiple incision along with change in posture of neck during the act explains the injury to the jugular vein on the left side. The involvement of Zone II and tear in internal jugular vein as seen in this case is in concordance with the previous studies conducted on the cut throat injuries which says that Zone II is the commonest zone to get affected in cut throat injury.[8,9,10]

Conclusion:

In our case the deceased has performed a single deep transverse

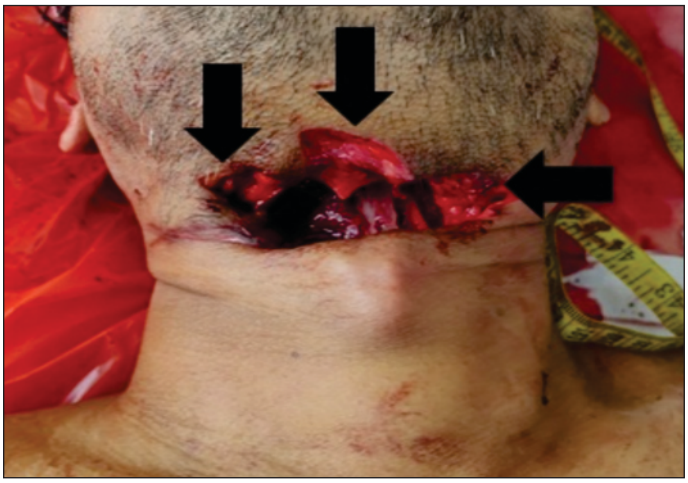

Figure 1: Multiple incised wound coalesced to form cut throat wound.

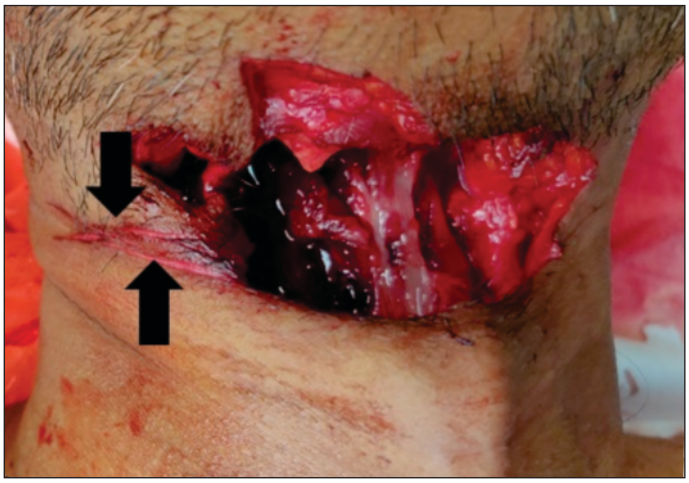

Figure 3 : Tailing is noted in two different directions.

Figure 2 : Tailing of the wound on the right side of neck (on neck hyperextension).

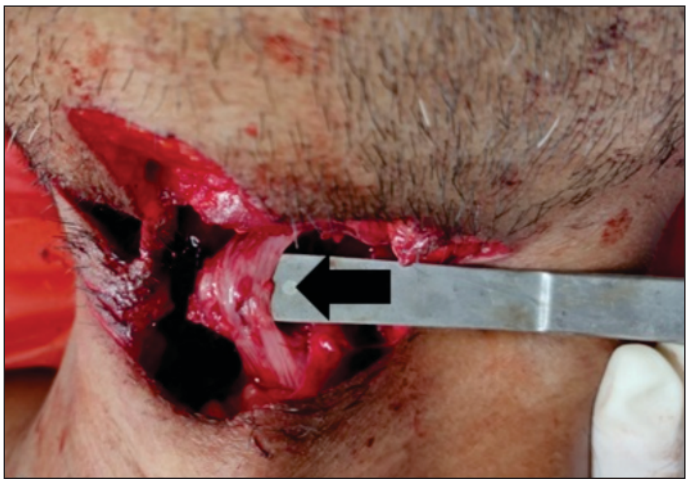

Figure 4 : A tear noted in left internal jugular vein.

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cut by hyperextending his neck. He has tried multiple times to deepen it by changing his head posture as shown by the direction of multiple deep cut wound involving the floor of mouth. The tailing observed in different directions also favours the above mechanism. There is neither hesitant cuts observed in the neck nor at the wrist suggestive of trial incisions which is the novelty of the case. Hence, we conclude that the deceased is a right-handed individual and committed suicide.

Authors' contributions:

All authors listed were actively involved in the preparation of manuscript and have approved the version to be published.

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The authors report no declarations of interest.

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The consent to participate was obtained from the relatives of the deceased.

Consent for publication:

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The presented content completely complies with the ethical standards of the authors' affiliated institutions. Ethics approval is not needed.

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Case Report

The Forensic Evaluation of Burnt Human Remains - A Case Report

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Abstract :

Burning and disposing the body in remote places has been used since ages in the history of mankind to evade the identity and to destroy the evidences of criminal act against individuals, but burning the body in the thickly populated area is rare. Such burnt corpses are challenging for forensic pathologists in view of identification, interpretation of injuries contributing to or causing death, whether the victim was exposed to the fire before or after death and in ascertaining the manner of death. Here we report one such case, where the partially burnt female body was found at the corner of an empty site, next to a bank on the main road, in the Metropolitan city of South India, which had gone unnoticed to public for more than a week. The various medico-legal issues associated with such a case are also being discussed in the light of available literature.

Keywords : : Burns; Postmortem burns; Homicide; Identification.

Introduction :

Burning is one of the common methods used by the assailants to dispose the body after homicide to evade the identity and to destroy the evidences of criminal act. Forensic pathologist play a vital role in identification, interpretation of injuries contributing to or causing death, nature of burns and in ascertaining the manner of death. Discovering a burnt body in an unfamiliar, outdoor or abandoned place, scene or autopsy findings attributable to a violent death, presence of accelerant use and absence of vital signs are factors indicative of postmortem burning following homicide.[1] In such instances identification becomes paramount importance in the investigation. Generally, positive identification is achieved by fingerprints, dental records, and comparison of antemortem/postmortem radiographs and DNA profile analysis. Postmortem identification of an unidentified body or of human remains is important to prove the legal aspects (citizens' rights and duties) and as well the social aspects (to put an end to the speculation about the missing person). Identification of the victim is the fundamental step in solving cases of homicide. This is especially difficult when the body is decomposed, skeletonized or burnt. Krogman and Iscan hypothesized that, the big four; age, sex, population affinity, and stature can provide the essential information to start a criminal investigation.[2] In cases involving extensive thermal alteration, it is often difficult for establishing positive identification because of the fragmentary condition of the remains of the material, which will hamper the use of standard identification techniques. In such cases, apart from identification, determining the cause and manner of death is a challenging task for the forensic pathologist. It is fundamental to look for an injury likely to be the cause of death other than the burns though it is difficult to interpret the injuries as to whether they are ante mortem or post mortem and as to their role in causing or contributing to death.[3] When death is related to fire, certain elements make it possible to assert that the victim was alive: presence of soot in the airways, oesophagus, and stomach, but it is difficult to ascertain the exact nature of burns (ante mortem or post mortem).[4] Here we report one such case of a partially burnt female body and associated medico-legal issues, along with relevant literature review.

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Case Report :

An unidentified, burnt, charred female body was found at the corner of an empty site, besides a bank, on a main road, in a metropolitan city of south India. A case of unnatural death was registered in the month of March, (usually temperature will be around 28-32^{o}C by the local corps and the investigation was initiated. The body was brought wrapped in a polythene sheet and kept in the morgue for 3 days in view of identification, and subsequently it was subjected for autopsy.

At autopsy, the body was burnt and charred with burnt smell emanating, and was separated at the level of neck and at pelvis, scalp hairs were burnt except for a few tufts of 10-12 cm long black hairs, over occipital region. [Fig.1] 5th- 6th degree (Dupuytren's) burns were present all over the body except the forearms and legs, which showed 1st to 2nd degree burns with decomposition changes at places over the forearm and legs, and maggots of 0.2 to 1.2 cms, eggs and empty pupal casings. The tissues of the neck were completely burnt and charred up to the cervical vertebra, separating the head from the trunk. Thoracic and abdominal contents were reduced to an unrecognizable burnt mass except for a portion of large intestine and uterus, with postmortem heat fracture of right arm bone at its upper 1/3rd and there were no other demonstrable skeletal injuries.

The articular surfaces/fractured ends of the various bones were

suggestive that the burnt separated head and lower limbs and body belongs to one and the same individual. The sex was determined from morphology of the burnt skeletal remains as female; the stature was determined to be 147 cm. Age was estimated to be 30-40 years by taking into consideration the various secondary ossification centres, dentition [Fig. 2 & 3] and sutural closure pattern in the skull [Fig. 4].

Left femur, mandible, tuft of scalp hairs, 3rd upper molar, and piece of muscle from thigh was preserved for DNA analysis and skin tissue bit and piece of muscle from the thigh was sent for chemical analysis for the detection of presence of any poison/fire accelerant.

Finally, it was inferred that, the remains were of human origin, belonging to a female individual of age about 30-40 years and time since death as 1-2 weeks prior to the post-mortem examination and burns were of post-mortem in nature. Subsequently during interrogation by the investigating officer of a nearby jurisdictional police station, it was found that husband confessed to the crime that, he had killed his 32-year-old wife by throttling and dumped the body in that empty site during night hours and doused the body with petrol and set on fire, due to her extramarital affairs and registered missing complaint after one week.

Discussion:

The identity of the corpse can be established by using the physical characteristics, descriptive data, identification marks, blood grouping etc., but in the charred body except the skeletal remains with few attached tendons and ligaments at joints no other structure will be available to establish the identity. In such cases if suspected victim has undergone any orthopedic surgeries, any dental procedure with prosthesis could be useful in identification. But in metropolitan cities like Bangalore where population growth rate is estimated to be of 47.18%.[5] The floating population is almost 60% of the total and many of them had come alone from all over the country to make their livelihood, it is difficult to keep identification data. In such floating population the next kin or relative won't be aware about where about of such person. Therefore no missing complaint is lodged by them with police when such person goes missing, making the identification task

Figure 1 : Burnt and charred body separated at the level of neck and pelvis.

Figure 2 : Dentition in Maxilla.

Figure 3 : Dentition in Mandible.

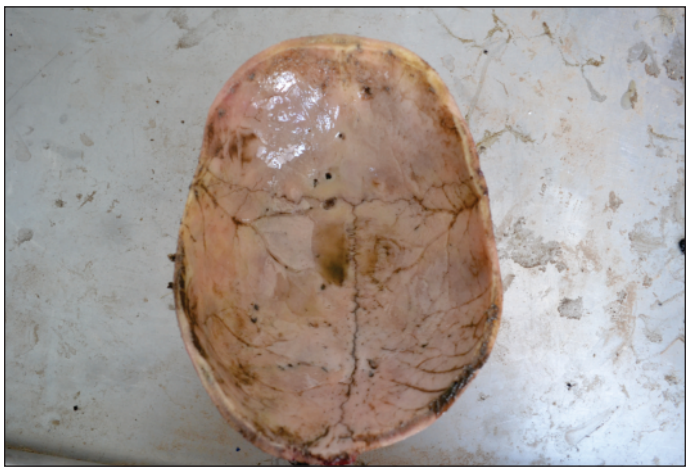

Figure 4 : Endocranial sutures.

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even more difficult. It is not only important during life but also after the death for the relatives to know about the death of their kith and kin which would put an end to their anxious wait for his/her arrival and the speculations about the manner in which the person had died, and also Indian population has diversity of religions and the various rituals followed in each religion are different not only during life but also following the death of an individual. Thus, it is the need of the day to maintain the identification data in all aspects for population of such metropolitan cities, majority of which is comprised by the floating population. The approach and problems encountered in establishing the identifying of the victim in case of postmortem burning has been discussed here.

The body was burnt and charred with burnt smell emanating. The tissues of the neck were completely burnt and charred up to the cervical vertebra, separating the head from the trunk. There was postmortem heat fracture of right arm bone at its upper 1/3rd and The articular surfaces/fractured ends of the various bones were suggestive that the burnt separated head and lower limbs and body belongs to one and the same individual. The burnt area on the lower limb did not show redness or any feature of ante mortem burns. The tuft of unburnt hair in the occiput, and burnt skin of the sole was also suggestive of post mortem burns. In case of doubt, analysis of the topography of the injuries and the unaffected zones may help to differentiate a case of self-immolation from a false immolation by post-mortem spraying with an inflammable liquid. In self-immolation, injuries usually predominate in the area of the head and the trunk. Classically, the soles of the feet are not burnt.[6] There were no other demonstrable skeletal injuries.

There were maggots of 0.2 to 1.2 cms, eggs and empty pupal casings, with advanced decomposition changes at places over the forearm and legs. Thus, the time since death was determined to be 1-2 weeks prior to the post-mortem examination.

Primarily, gross examination of the skull, pelvis and long bones can be used for determination of sex and to confirm precisely muscle tissue, molar tooth and/or femur bone can be used for DNA analysis to prove.[8] In the present case, the sex of the individual was determined from the gross morphological features of the burnt skeletal remains (mainly the pelvis, skull and mandible), as female.

The stature was calculated from height of the skull with mandible (calculated by multiplying the height of skull with mandible i.e., 21 cms x 7= 147 cms and also by using Pan formula for femur in Indians is length of femur x multiplication factor i.e. 47 x 3.08, approximately 145 cm by adding 2 cm to soft tissue it was estimated that the stature was 147 cm.[7] Age estimation was determined by fusion of various secondary ossification centres, dentition, sutural closure pattern in the skull and the changes in the medial surface of the pubis by todd's criteria. The basi-occiput and basi-sphenoid suture was fused and all other suture were not fused both ecto and endo cranially. All permanent teeth were erupted in all quadrants. All secondary centres for various long bones (Humerus, Radius, Ulna, and Femur etc.) and those for iliac crest, ischial tuberosity and all sacral vertebrae had fused. The medial surface of the pubis showed faint transverse ridges with granular surface and ill-defined ventral (outer) and dorsal (inner) margins.[8]

Left femur, mandible, tuft of scalp hairs, 3rd upper molar, and piece of muscle from thigh was sent for DNA analysis and skin tissue bit and piece of muscle from thigh was sent for chemical analysis for the detection of presence of any poison/fire accelerant. Petrol (fire accelerant) was not detected in the skin tissue bit; no poison was detected in the muscle tissue sent.

In a study done in Turkey thirteen cases of homicide involving postmortem burning were analysed. The cases were examined with regard to age, gender, place of death or discovery, autopsy findings, accompanying injuries and manner of death. Eleven of the cases were male and two were female. Victims' ages ranged between 24 and 62 years with a mean age of 43.5 years. All of the victims were discovered in unfamiliar places. Autopsy findings indicated postmortem burning of corpses to cover homicide. Discovering a burned body in an unfamiliar, outdoor or abandoned place, scene or autopsy findings attributable to a violent death, presence of accelerant use and absence of vitality signs are factors indicative of postmortem burning following homicide.[1]

Similarly in our case, victim was an adult female aged between 30-40 years with post mortem burns. Time since death was determined to be 1-2 weeks prior to the post-mortem examination; however exact cause of death could not be determined. Subsequently during interrogation by the investigating officer of a nearby jurisdictional police station, it was found that husband confessed to the crime that, he had killed his 32-year-old wife by throttling and dumped the body in that empty site during night hours and doused the body with petrol and set on fire, due to her extramarital affairs and registered missing complaint after one week. The fire accelerant (Petrol) was not detected since the body had gone unnoticed after 10 days, and thus it would have been evaporated. The neck structures were completely charred, thus it was not possible to find the actual cause of death (evidence of throttling).

Conclusion :

In thickly populated countries like India, it is difficult to establish identity from the burnt human remains due to non-availability of the ante-mortem data of any orthopedic appliances, dentures and DNA profiling of the individuals. Forensic pathologists should keep in mind that, they should carefully collect evidence so as to aid in positive identification, ascertaining the cause, manner of death and time since death, thereby assisting the investigating officer in solving the mysteries behind such deaths

Conflict of interest :

The authors state that there are no financial and personal relationships with other people or organizations that could inappropriately influence this work.

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REVIEW ARTICLE

Admissibility of Serving Summons and Warrant by Electronic Media: An Indian Perspective

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Abstract :

In India, receiving summons and warrant for one or the other cases by the general public particularly by the medical professional for providing evidence in the court of law is the usual scenario. In addition to the routine procedures, some electronic modes of delivery of this legal document particularly internet-based media such as emails and whatsapp have been approved by Indian law. Awareness regarding the applicability of the same is however lacking in our society. Though these reforms are essentially required for speedy trial and up-gradation of our judicial process, they cannot replace the traditional/ regular modes of delivery.

Keywords : Summons; Warrant; Evidence; Court; Law; Electronic.

Introduction :

Summons or subpoena is a legal document issued in duplicate, compelling the appearance of the person in the court related to any case or to the person accused or a witness, to appear in a particular court on a particular day for a particular purpose under penalty.[1]

The primary method of serving summons is by personal service, which means that a police officer, an officer of the court, or any other public servant must physically deliver a copy of this document to the concerned person. Alternatively, if the person summoned cannot be found, it may be served by leaving a duplicate copy with some adult member of his family residing with him, or if it cannot be serviced, even after due diligence, then a copy of the summons has to be affixed on some conspicuous part of the house in which the defendant ordinarily resides. In cases when the summons is to be served in prison or outside India, it can be done by post or by courier service as may be approved by the High court or by fax or by electronic mail service.

In India, despite the efforts, due to a number of reasons including shortage of manpower, limited resources, and insufficient training of personnel, serving of these legal documents is still not done in a time-bound manner. There by, causing a delay in the adjudication of the case and unfortunately, the judicial process suffers. Hence, there is a dire need for some innovative judicial reforms that can help speed up this process of dispensation of justice. One such tool which appears to be promising is the serving of summons or any other legal notice by internet-based media such as Whatsapp but like any other official procedure, this too carries some judicial restrictions which will be discussed ahead in detail.

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Discussion:

In this era of modernization in technology, any information is just a click away through easily accessible internet services. Recently, utilization of these advancements for facilitating legal proceedings by the Indian judiciary too has been on the verge.

In addition to the traditional procedures being followed, after amendment in the Information Technology Act[2] and subsequently in the Indian Evidence Act (section 65A & 65B)[3] in 2000, which now recognizes electronic communication such as email and text messages as evidence, courts have allowed legal notices through these media. Therefore, it can be construed that usage of electronic social media e.g. Whatsapp, Facebook, etc. by the court does not seem to be against legal provisions.

The court has indeed expanded the scope of electronic media by using Whatsapp to serve summons. First such instance happened in the State of Haryana where financial commission headed by an IAS officer in the matter of property dispute allowed the serving of summons through Whatsapp to one of the respondents who had shifted to Kathmandu.[4] In August 2018, the Bombay high court held that "the court can take into account the modern ways of service which are available due to internet connection. It can be served also by courier or by email or by Whatsapp etc." Since then, there have been numerous instances where the court has allowed such electronic means of communication for speedy trials in order to expedite the delivery of justice.[5-12] The admission of WhatsApp in these court proceedings was the last resort and it was adopted when all the ordinary methods failed.

Amongst the various instant messaging apps, Whatsapp has particularly gained a lot of popularity in the past few years. As a matter of privacy in the app, there is a feature of double tick for delivery of the message and a blue tick indicating that the respective message has been opened/read by the recipient. Though, itrequires some modification to be made in the privacy settings of the app in their account i.e. it is solely upto the discretion of the user whether he/she wishes to switch on 'read receipts' or disable it altogether.[13] Tweaking the settings in this manner would give an erroneous impression that the person has

not received the summons while in reality he/she has received and gone through it.

The question arises, whether delivery of summons through Whatsapp should be completed with a double tick or a blue double tick as many users do not use the blue tick mark as discussed above. Another important question for consideration can possibly arise when a case is adjudicated on the basis of service of summons through Whatsapp, but it is later found that the intended defendant was actually not using the number on which the service was delivered.

Moreover, the court makes submission of an affidavit mandatory to assure that the right person is actually being served the summons. The question still arises, what if the WhatsApp number is changed and summons served to someone else were not explicitly dealt with by the court in such cases. Hence, it becomes the duty of the party who is giving the required contact details to ensure that the summons is served to the right person.

As mentioned earlier, once an arrest warrant is issued it remains in force until cancelled by the Court who issued it, or until it is executed. This means, unless surety and security amount is obtained by the serving officer, it needs to be executed by producing him/her before the Court which issued the warrant or executive magistrate or district superintendent of police or Commissioner of police within the local limits of whose jurisdiction the arrest was made. Both for obtaining surety and for arresting, the serving officer is required to be physically present with the original document; neither of these seems to be feasible in the absence of personal delivery of warrant. Hence, there is still no clarity regarding its validity or admissibility in the court of law.

Conclusion :

In the Indian scenario, considering the scarcity in manpower, limited availability of resources, and requirement of a speedy trial, serving of legal notices through electronic media is definitely a welcome step into up-gradation of our judicial process. However, awareness regarding these updated legal provisions for delivery of Summons should be made to the general public, in order to avoid any harassment for non-compliance. On the other hand, clarity and corresponding amendments in the procedural laws regarding delivery of warrant of arrest through electronic media is also to be made followed by its awareness. Nevertheless, it is essentially important to understand that such electronic means, particularly Whatsapp, are not going to replace the traditional/regular modes of delivery and are only meant for those exceptional cases where the defendants are hiding and evading their appearance in courts.

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Pooja Rastogi	Associate Professor	SSOR Noida
Rajiv Joshi	Professor & Head	GGS Medical College, Faridkot, Punjab
Sanjay Sukumar	Additional Professor	JIPMER, Puducherry.
Saurabh Chattopadhyay	Professor	NRS Medical College, Kolkata
Tapas Kumar Bose	Professor & Head	NRS Medical College, Kolkata
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