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Contents

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EDITORIAL

Forensic Anthropology: An overview of the various avenues in human identification

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Human identification is one of the most crucial aspects of Forensic Anthropology. It is a vital function that Forensic Medicine experts and Forensic Anthropologists perform. Human identification involves application of the science of human anatomy, osteology, and anthropology.[1] Identification is required in both the living and the dead, and in civil as well as criminal cases. In the living, human identification is done in cases of war refugees, asylum seekers, victims of solicitation and trafficking, etc. while in the dead, it is done in cases of skeletal remains, putrefied bodies, and charred and dismembered human remains.[2]

Traditionally, anthropological research has been focused on use of 'Big three' of human identification; estimation of sex, age, and stature. Advances have been made into newer fields of identification such as DNA profiling using skeletal evidence, analysis of commingled remains, forensic taphonomy, histology and microscopy of bones, facial reconstruction and skull photo superimposition, mechanics of bone trauma, and isotope analysis.[3]

In case of multiple skeletal remains, anthropologists have always had to answer how many individuals have contributed to the skeletal remains in question. Traditionally, this was done by sorting left and right-side bones, age, and estimated stature using such bones. Development of computer algorithms and applications that establish probabilities of multiple bones belonging to the same individuals have eased the issues related to analysis of commingled remains.[4] These computer algorithms can be used to produce a number of potential pairs between bilateral bones, or they can be used to estimate the minimum number of individuals by including the percentage of missing or fragmented bones in already established formulae.[5]

Positive identification of human/ skeletal remains is conventionally based on the estimation of the 'Big Three' and matching of individualistic features on bones such as calluses, implants, or any congenital anomaly with antemortem data, if available. Since the advent of DNA profiling technology in the late 20th century, forensic scientists and molecular biologists all across the globe have researched newer and better ways of isolating DNA from skeletal evidence, and profiling it for purposes of human identification.[6-8] Molecular analysis has allowed the scientists and disaster victim identification experts to come up with ways of identifying unknown individuals based upon their DNA.

One of the major fields of research in forensic anthropology is forensic taphonomy, which is the study of decomposition of human remains. Establishment of body farms across the globe that examine the minute changes that occur in a cadaver, have helped scientists generate robust models to predict the post mortem interval. Apart from investigating the changes in a cadaver itself, scientists have been making strides in studying the effects of soil conditions, ambient environmental conditions, presence or absence of clothing, depth of the grave, humidity and moisture of the grave site, etc. on the rate of decomposition. Furthermore, research into degradation of proteins, enzymes, and RNA molecules to estimate the post mortem interval has added new tools in the arsenal of forensic professionals for estimating time since death of an individual.[9-10]

Osteon counting for age estimation, and study of haversian systems to determine the origin of species of a questioned bone, are some of the newer applications of bone microscopy and histology that have revolutionized the science of human identification.[11] Recent advances into study of isotopes have allowed scientists to comment upon the diet of the victim, origin of a migrant, long term adult residence, recent travel history, age at death etc.[12]

Human identification via means of forensic facial reconstruction and skull photo superimposition has been around for decades. However, recent technological advances have equipped forensic anthropologists with means to generate real time 3D scans of the skull and face to streamline the process of identification. Use of machine learning algorithms and convoluted neural networks to better assess the relationship between skeletal substrate and overlying soft tissues, as well as use of 3D computer animation tools such as Blender, have allowed forensic anthropologists to reproduce a fairly accurate virtual representation of the face of an unknown individual from their skull.[13]

One of the toughest tasks for a forensic medicine professional is determining whether an injury present on the cadaver is ante-mortem, peri-mortem, or post-mortem in nature. Assessment of biomechanical forces that play a role in trauma and injury to the bone have allowed medicolegal professionals to differentiate between the three injuries. Employing an understanding of bone mechanics, along with radiological tools such as

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microcomputed tomography has allowed forensic professionals to understand the nature of an injury.[14-15] Medicolegal professionals can thus opine about the cause of death of an individual with more certainty by applying the principles of bone trauma biomechanics.

The advances in the science of Forensic Anthropology have thus, helped Forensic experts in providing more accurate and quicker results regarding the identity of unknown human remains. Further population specific research on the aforementioned subjects will ensure dynamic and rapid growth of Forensic Anthropology as a science.

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ORIGINAL ARTICLE

Bone age estimation using epiphyseal fusion of tibia & fibula and lower end of femur in females

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Abstract

through childhood, puberty, and finishes growth as a young adult, the bones of the skeleton change in size and shape. Long bone growth takes place at the epiphyseal or growth plate, located between the metaphysis and epiphysis. Age estimation is an important medical examination in civil and criminal cases, where there are no documents available to certify the age, especially in developing countries like India. There are various methods for age estimations, like dental examination, general physical examination X ray examination of various bones etc. X ray examination of bones especially for ossification and the union of epiphyses give relatively reliable results. In criminal cases involving minors as per POCSO Act,age of sexual assault victim is also crucial as different clause applies for minors. Courts totally depend on medical report for age provided by board of doctors. It is therefore a huge responsibility on the doctors to be accurate with least degree of error. Keeping accuracy in the mind the present study was undertaken. 100 females between 10 to 21 were X-rayed and divided in 4 categories (Degree 0- Degree 3) depending on the status of fusion of long bones. 100 % female showed complete fusion at distal end of femur at the age group of 15-16, Proximal end of tibia at the age group of 16-17, proximal end of fibula at the age group of 15-16, distal end of tibia at the age group of 14-15 and distal end of fibula at the age group of 14-15.

Keywords

Epiphyseal fusion; Femur; Tibia; Fibula; Age estimation

Introduction

In India, there are millions of people without any certificate / document to certify the true age. Judiciary faces difficulties in ascertaining the age in cases of juveniles in conflicts with law and rape victims. In these cases, law looks forwards to the medical examination of the person for age estimation. For providing the exact chronological age and biological age estimation, it is necessary to combine information from general physical examination, dental examination and X-ray examination of bones. During growth of human beings from childhood and then puberty to adulthood, bones increase in length and size. Epiphyses of bones unite at a particular age and these changes in epiphyseal union help to find the skeletal age, which when analysed with age-based models, which give a chronological age estimation.[1]

Macroscopic and microscopic methods can be utilised to find out the real age of a human beings by medical expert. The microscopic method basically use Osteon counting is usually depended upon remodelling of long bones. Macroscopic methods include: dental growth, analysis of general physical development (Height and Weight), puberty changes (Secondary sexual characters) and bones ossification. X-ray examination is most reliable and commonly used method of age estimation in living human being. The arising of secondary ossification centres are used for analysing age and also the epiphysis union timing.[2]The lower limb long bones play a vital role in age calculation both in living and dead persons. There is immense difference in the data not only in India but also abroad owing to different environmental situations and socioeconomic pattern.[3]

Forensic experts use a range of parameters for estimation of age. These parameters are physically examined by a suitably qualified medical expert, age estimation by using dental radiographic assessment of denture[, 6] X-rays examination of epiphyseal fusion of bones

The femur is the strongest and longest bone of the skeleton. The femur, like other long bones, is divisible into two extremities and shaft. The femur ossifies from five ossification centres one each for the shaft, head, greater and lesser trochanters and the distal end. The distal end fuses in females after seventeenyears[.5]The tibia lies medial to the fibula and is engaged directly in the transmission of weight and having a shaft and two extremities. It starts from three centres, one each for the upper and lower end and one for the shaft. Ossification starts in mid shaft at about an intrauterine seventh week. The proximal epiphysis fuses in females in the sixteenth year. The distal epiphyseal centre origin early in the first year of life and

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joins the shaft among females in about the fifteenth year.[6] The fibula is very lean than the tibia and is not involved directly in the transmission of weight. It has a proximal head, a long shaft, a narrow neck, and a distal lateral malleolus. The shaft unites with the distal epiphysis in females at about fifteenth year, whereas the proximal epiphysis unites at about seventeenth year[7]

So, ossification of secondary centres and their display is usually used for age estimation that is the time of epiphyseal fusion. Countable differences may be analysed in the fusion activities and appearance of ossification centres based upon race, sex, and geographical distribution. The food, nutritional status, habit, and presence of some diseases, physical activity and hormonal and metabolic disorders may also control the ossification process.[8]

Materials and Methods

The present study was carried at Forensic Medicine Department and Radiology department of M.M.I.M.S.R, Ambala Haryana, India. Study period was from December 2015 to May 2017. During the study period, 100 females in the age group of 11-21 years were selected by using random sampling and confirming the age by Aadhar card, birth certificate, ration card, passport or matriculation certificate whosoever came for x-ray. A prior approval was obtained from the Institutional Ethics Committee. The purpose was explained to the subjects and written informed consent was obtained for the x-ray. X-rays of knee and ankle joints in anterior-posterior (AP) view were taken and the status of fusion of the epiphyses was noted. Radiographs of all subjects were studied and age was estimated by the modification of the criterion as described by O'Connor et al.[15]as follows:

Degree 0: A dark radiolucent line seen throughout the length of the epiphyseal and metaphyseal joining surfaces (Fusion not yet commenced)

Degree 1: Radio-opaque area is seen in the middle or on either side of the epiphyseal and metaphyseal joining surfaces (Fusion commenced)

Degree 2: Radio-opaque area is more than half of the epiphyseal and metaphyseal joining surfaces (Fusion incomplete)

Degree 3: Radio-opaque area is seen in the entire length of the epiphyseal and metaphyseal joining surfaces (Fusion Complete)

SPSS (Statistical Package for the Social Sciences) version 20.0 was applied and the results were analysed. The values were represented in Number (%) and Mean ± SD.

Results

Epiphyseal fusion of distal end of femur started from the age group 12-13 years onwards. Complete fusion was observed in age group 15-16 years (Table 1). In the present study as no overlapping of degree of fusion is observed in different groups, so final age of fusion was taken to be 15-16 years.

Table 1: Status of fusion of the distal end of femur

Female		Distal end of Femur				P value
Age (years)	N	0	1	2	3	
11-12 Years	6	6	0	0	0	
12-13 Years	3	0	3	0	0	
13-14 Years	4	0	4	0	0	
14-15 Years	8	0	0	8	0	
15-16 Years	13	0	0	0	13	**<0.001**
16-17 Years	17	0	0	0	17	
17-18 Years	16	0	0	0	16	
18-19 Years	11	0	0	0	11	
19-20 Years	13	0	0	0	13	
20-21 Years	9	0	0	0	9	

Table 2: Status of fusion of the proximal end of tibia

Female		Proximal end of Tibia				P value
Age (years)	N	0	1	2	3	
11-12 Years	6	6	0	0	0	
12-13 Years	3	3	0	0	0	
13-14 Years	4	4	0	0	0	
14-15 Years	8	0	8	0	0	
15-16 Years	13	0	0	13	0	<0.001
16-17 Years	17	0	0	0	17	
17-18 Years	16	0	0	0	16	
18-19 Years	11	0	0	0	11	
19-20 Years	13	0	0	0	13	
20-21 Years	9	0	0	0	9	

Table 3: Status of fusion of the distal end of tibia

Female		Distal end of Tibia				P value
Age (years)	N	0	1	2	3	
11-12 Years	6	6	0	0	0	
12-13 Years	3	0	3	0	0	
13-14 Years	4	0	0	4	0	
14-15 Years	8	0	0	0	8	
15-16 Years	13	0	0	0	13	<0.001
16-17 Years	17	0	0	0	17	
17-18 Years	16	0	0	0	16	
18-19 Years	11	0	0	0	11	
19-20 Years	13	0	0	0	13	
20-21 Years	9	0	0	0	9	

Table 4: Status of fusion of the proximal end of fibula

Female		Proximal end of Fibula				P value
Age (years)	N	0	1	2	3	
11-12 Years	6	6	0	0	0	
12-13 Years	3	0	3	0	0	
13-14 Years	4	0	4	0	0	
14-15 Years	8	0	0	8	0	
15-16 Years	13	0	0	0	13	<0.001
16-17 Years	17	0	0	0	17	
17-18 Years	16	0	0	0	16	
18-19 Years	11	0	0	0	11	
19-20 Years	12	0	0	0	12	
20-21 Years	9	0	0	0	9	

Table 5: Status of fusion of the distal end of fibula among females

Female		Distal end of Fibula				P value
Age (years)	N	0	1	2	3	
11-12 Years	6	6	0	0	0	
12-13 Years	3	0	3	0	0	
13-14 Years	4	0	0	4	0	
14-15 Years	8	0	0	0	8	
15-16 Years	13	0	0	0	13	<0.001
16-17 Years	17	0	0	0	17	
17-18 Years	16	0	0	0	16	
18-19 Years	11	0	0	0	11	
19-20 Years	13	0	0	0	13	
20-21 Years	9	0	0	0	9	

Epiphyseal fusion of proximal end of tibia started from the age group 14-15 years. Complete fusion was observed in age group 16-17 years (Table 2). In the present study as no overlapping of degree of fusion is observed among different groups so final age of fusion was taken to be 14-15 years.

Ossification started from age group 12-13 years. Complete fusion was observed in age group 14-15 years (Table 3). No overlapping of degree of fusion is observed among different groups so final age of fusion was taken to be 14-15 years. Ossification started from age group 12-13 years. Complete fusion was observed in age group 15-16 years (Table 4). No overlapping of degree of fusion is observed among different groups so final age of fusion was taken to be 15-16 years. Ossification started from age group 12-13 years. Complete fusion was observed in age group 14-15 years (Table 5). No overlapping of degree of fusion is observed among different groups, so final age of fusion was taken to be 14-15years. Table 6 is showing comparison between present study and various Indian and foreign studies. In present study complete fusion of distal end of femur bone was noticed in the age groups 15-16 years. With regard to complete fusion of distal end of femur, these findings are consistent with studies done by Agarwal & Pathak.[12] In the present study complete fusion of proximal end of Tibia bone was noticed in the age groups 16-17 years. With regard to complete fusion of proximal end of Tibia, this finding was consistent with studies done by Saxena & Vyas, [13] Singh et.al[20] and Johnston.[22] In the present study, complete fusion of proximal end of fibula bone was noticed in the age groups 15-16 years. With regard to complete fusion of proximal end of fibula, this finding was consistent with studies done by Agarwal & Pathak[22] In the present study, complete fusion of distal end of Tibia bone was noticed in the age group 14-15 years. With regard to complete fusion of distal end of Tibia, this finding was consistent with studies done by Pillai, [9] Bokariya et al.[16] and Flecker.[23] In the present study, complete fusion of distal end of Fibula bone was noticed in the age groups 14-15 years. With regard to complete fusion of distal end of Fibula, this finding was consistent with studies done by Pillai[9] and Flecker.[23]

Table 6: Comparison of age of epiphyseal fusion (years) of femur, tibia, and fibula observed in the present study with that given in the literature

Study	Region/ population	Distal femur	Proximal tibia	Distal tibia	Proximal fibula	Distal fibula
Indian Studies/Text books of Forensic Medicine						
Reddy[7]	NA	17-18	17-18	16-17	17-18	16-17
Rao[1]	NA	17-18	17-18	16-17	17-18	15-16
Anil Agarwal[2]	NA	17-18	17-18	16-17	17-18	16-17
Pillai[9]	Chennai	14-17	14-17	14-17	14-17	14-17
Galstaun[10]	West Bengal	14-17	14-15	13-15	14-16	13-15
Agarwal & Pathak[12]	Punjab	15-16	15-16	15-16	15-16.5	15-16
Narain & Bajaj[11]	Uttar Pradesh	18-19	18-19	17-19	18-19	17-19
Saxena & Vyas[13]	Madhya Pradesh	18-19	16-17	-	16-17	-
Das Gupta et al.[14]	Uttar Pradesh	16-17	17-18	-	-	-
Bokariya et al.[16]	Rajasthan	16-17	14-15	14-15	16-17	13-15
Nemade et al.[17]	Vidarbha	16-17	17-18	-	18-19	-
Singh et al.[19]	Uttar Pradesh	16-17	16-17	-	-	-
Basu & Basu[24]	Hindu	-	15-16	15	16-17	15
Present Study	Haryana	15-16	16-17	14-15	15-16	14-15
Research publications						
Johnston[21]	Native Americans	17-18	16-18	-	16-17	-
Hansman[22]	USA	12-17	12-17	-	12-17	-
Connor & Bogue [15]	Ireland	17-17.9	17-17.9	-	17-17.9	-
Ding et al.[18]	Tibetan	14-19	-	-	-	-
Ebeye et al.[20]	Nigeria	18.1-19	17.1-18	-	16.1-17	-
Flecker[23]	Australian	-	14-19	14	17	14-15
Davies & Parson [25]	England	-	-	18	-	18
Chritian [26]	Mexican Americans	-	-	16	-	16
Crowder & Austin[27]	European Africans	-	-	16	-	16

Discussion

Age of epiphyseal fusion of distal end of femur was observed in age group 14-15 years. Age of fusion is consistent with only one Indian study. Most of the Indian and foreign studies observed the age of fusion more than present study extending up to 18-19 years. Age of fusion of proximal end of tibia was observed in age group 16-17 years. Age of fusion is consistent with two Indian and one foreign study. Other Indian and foreign studies observed the age of fusion both less and more the present study extending from 14-15 years to 18-19 years. Age of fusion of proximal end of fibula was observed in age group 15-16 years. Age of fusion is consistent with two Indian and non-foreign study. Other Indian and foreign studies observed the age of fusion both less and more than the present study extending from 14-15 years to 18-19 years Age of epiphyseal fusion of distal end of tibia was observed in age group 14-15 years. Age of fusion is consistent with only one Indian study. Most of the Indian studies observed the age of fusion more than present study extending up to 17-19 years. Age of epiphyseal fusion of distal end of fibula was observed in age group 14-15 years. Age of fusion is consistent with only one Indian and one foreign study. Most of the Indian studies observed the age of fusion both less and more than the present study extending from 13-15 years to 17-19 years.

Conclusion

When we compare age of fusion of femur, tibia and fibula bones as per various Indian textbooks and all the Indian & Foreign studies, we find that age of fusion is less up to 2-3 years in most of the Indian studies than the age of fusion as per text books. When we compared age of fusion of femur, tibia and fibula bones as per various Indian textbooks and foreign studies we find that age of fusion as per textbooks is consistent with most of the foreign studies. This comparison suggests that most of the Indian text books are quoting foreign studies as references which are not consistent with most of the Indian and the present study. We are consistently giving our age estimation reports in all the medico legal cases as per the standard Indian textbooks which seem to be inaccurate for Indian population. A systematic review of all the Indian studies needed to be conducted to provide a more accurate reference for age estimation for Indian population.

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ORIGINAL ARTICLE

Can the patella be used to estimate age in an Indian population?

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Abstract

Identification is the individuality of a person. The requirement to establish the identity of the deceased is required in wide categories of cases like in criminal investigation, mass disaster incidents or in war crimes and genocide. There are four basic categories associated with biological identity i.e., sex, age-at-death, stature, and ethnic origin. Age estimation can be determined by teeth, ossification of bones, secondary sex characteristics, general development etc. Age related changes are found in teeth, pubic symphysis, vertebrae, mandible. It can also be done by studying ossification of lower and upper limbs bones, sternum, cranial sutures, hyoid bone, hip bone, sacrum etc. The objective of the present paper is to find out whether the age may be estimated from the dimensions of patella in males and females or is there any impact of age on osteometric mesaurements of patella. The study explored nine parameters of patella bone from both sides in males as well as in females. A total of 199 (49.8%) were taken from males and 201 (50.2%) were obtained from females. Among males, no significant difference in measurements across different age groups was observed on all parameters except Specific Gravity (SG) at both sides which was seen to be higher in younger age group as compared to older age groups ($p<0.05$). Among females too, statistically no significant difference in mean values of different parameters was observed among different age groups. The findings of the study suggested that, there is no significant effect of age on patellar dimensions except specific gravity in males.

Keywords

Osteometry; Patella; Identification

Introduction

Identification is the act of establishing the identity. The requirement to establish the identity of the deceased is required in wide categories of cases like in criminal investigation, mass disaster or in war crimes and genocide.[1]It is establishment of individuality of a person living or dead. It may be of two types- Complete/Absolute identification and Incomplete/Partial identification.[2] Identification especially needed for the information which comprises few major aspects i.e. to establish the fact of death in respect of that individual, for official, statistical and legal purposes; to record the identity for administrative purposes; to discharge legal claims and obligations in relation to property, estate and debts; to prove claims for life insurance contracts, survivor's pensions, and other financial matters; to allow legal investigations to proceed with a firm knowledge of the identity of the deceased to facilitate police enquiries into overtly criminal or suspicious deaths, as the identity of the deceased person is a vital factor in initiating investigations.[3]

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The establishment of identity may be required upon in cases of intact fresh corpses, decomposed corpses, mutilated corpses, dismembered corpses and skeletonised material.[3] Mutilation of the dead body is either done by criminal to destroy all traces of identity and thus facilitate the disposal of the dead, or it may be caused by scavengers.[4] The skeletal remains are helpful in identification of the victim, the nature and mode of death, and also the modus operandi adopted by the criminal. As such forensic experts are important in establishing the corpus delicti. The corpus delicti can be any part of a skeleton that appears to the expert to be human and to confirm to the description of the suspected victim.[5]

There are four basic categories associated with biological identity: sex, age-at-death, stature, and ethnic origin. Each of these, taken either in isolation or collectively, allow a preliminary picture to be built regarding the possible identity of the deceased.[6] Determination of sex in non-skeletonised bodies is usually obvious and rarely presents problems. In general, the external genitalia remain recognizable until a late stage of putrefaction. In addition, breasts and general body shape, as well as the pattern of pubic hair, reveal the sex. Where putrefaction is advanced, examination of the internal pelvic organs may still reveal unequivocal evidence of sex. The uterus is the organ in the body most resistant to decomposition, though the prostate is also quite persistent. Sex can also be determined by morphological and osteometric measurements of various human bones. Even patella can also be used for sex

determination.[7]

It is not easy to determine age and sex in cases of mutilated or skeletonised remains where dead body is destroyed by scavenging or other activities. Age estimation can be determined by teeth, ossification of bones, secondary sex characteristics, general development in case of children etc.[8] Age related changes are found in teeth, pubic symphysis, vertebrae, mandible[8]. It can also be done by studying ossification of lower and upper limbs bones, sternum, skull sutures, ribs, hyoid bone, hip bone, scapula, sacrum etc.[8] However not much of literature is available for age determination from patella.

The patella ossifies from a single centre, which usually makes its appearance in the second or third year, but may be delayed until the sixth year. More rarely, the bone develops by two centres, placed side by side. Ossification completes around the age of puberty.[9] Here in this paper, our aim is to find out the impact of age on osteometry of patella in both males as well as in females.

Materials and Methods

The present cross-sectional study is a part of the larger study done in the department of Forensic Medicine & Toxicology at Pt B D Sharma PGIMS, Rohtak, Haryana. A total of 400 subjects (199 males and 201 females) from both sides were chosen during post-mortem examination after taking proper written consent from legal heirs or police (in unknown subjects). Institutional Ethics Committee approval was also taken before starting the study. Only intact patellae from known sex and age were included for the study. However, patellae showing any signs of pathology or showing any kind of abnormality (congenital as well as acquired) were excluded from the study.

The cases were divided into four age groups, i.e., <18 years, 18-40 years (young adult), 40-60 years (middle age) and >60 years (old age).

The following measurements of each patella were taken in accordance to the previous studies.[10-12]

- Maximum height (MAXH)—the greatest distance between the base and apex.
- Maximum breadth (MAXB)—the greatest distance between the medial and lateral sides.
- Maximum thickness (MAXT)—the greatest distance between the anterior and posterior surface.
- Height of articular facet (HAF)—maximum height of the articular facet on the posterior aspect of the patella.
- Medial articular facet breadth (MAFB)—distance between the medial edge of the patella and the median ridge of the articular facet.
- Lateral articular facet breadth (LAFB)—distance between the lateral edge of the patella and the median ridge of the articular facet.
- Weight of patella (Wt)
- Volume of patella (Vol)
- Specific gravity of patella (SG) = Density of bone/Density of water (4°C)

Measurements were taken using a vernier calliper (Figure 1 and 2). In addition, a water displacement method was used for measuring volume of bone. In this, each sample was submerged into a graduated container containing water and the displacement method was used to calculate volume of bone. Specific gravity was measured by using weight and volume of bone and density of water. Specific gravity is the ratio of density of substance with the reference sample usually taken as water at specified temperature and pressure. All the measurements including specific gravity were studied to see any changes with age.

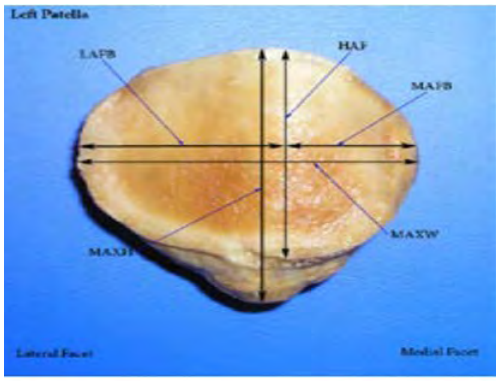

Figure 1: Various measurements of patella in anterior view

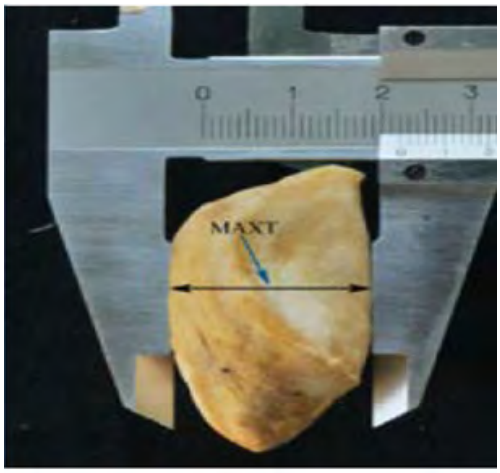

Figure 2: Lateral view of patella showing measurement of maximum thickness (MAXT) by vernier calliper

Results

The present study was carried out in the department of Forensic Medicine & Toxicology with an aim to find out the impact of age on patella osteometry. For this purpose, 400 specimens were taken from the two genders. Out of 400 samples included in the study, a total of 199 (49.8%) were taken from male and 201 (50.2%) were obtained from females.

Table 1: Number of male and female in different age groups

Age (years)	Total	Males (n=199)		Females (n=201)	
		N	%	N	%
<18	18	7	3.5	11	5.5
18-40 (Young adult)	276	115	57.8	161	80.1
40-60 (Middle age)	88	64	32.2	24	11.9
>60 (Old age)	18	13	6.5	5	2.5

χ^2=30.284 (df=3); p<0.001

Table 2: Descriptive statistics of various measurements of patella in male (199) population of different age groups & statistical significance between two variables

Parameter	<18 years (n=7)		18-40 years (n=115)		40-60 years (n=64)		>60 years (n=13)		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	P
Right side										
MAXH	43.44	2.83	43.00	2.67	43.14	3.07	44.84	2.40	1.714	0.165
MAXB	41.70	2.07	42.24	2.68	42.54	3.54	42.88	2.72	0.396	0.756
MAXT	22.73	1.93	21.72	1.68	21.61	1.74	21.93	1.93	0.933	0.426
HAF	31.27	2.20	31.61	2.86	31.71	3.09	31.72	2.83	0.055	0.983
MAFB	23.85	1.81	23.28	1.41	23.23	1.47	23.62	2.14	0.573	0.634
LAFB	27.21	1.87	27.45	2.23	27.62	2.17	28.24	2.75	0.569	0.636
Wt(g)	16.52	1.15	16.29	1.49	16.20	1.48	16.76	1.66	0.552	0.647
Vol(ml)	13.71	1.38	13.88	1.43	13.64	1.21	14.31	1.55	1.000	0.394
SG	1.21	0.06	1.18	0.04	1.19	0.04	1.17	0.03	3.197	**0.025**
Left side										
MAXH	42.92	3.57	42.60	2.76	42.67	3.15	44.46	2.67	1.619	0.186
MAXB	41.12	2.57	41.75	2.79	42.09	3.09	43.01	3.28	0.993	0.397
MAXT	21.89	2.29	21.24	1.65	20.96	1.82	21.49	2.05	0.895	0.445
HAF	30.70	2.42	30.87	3.00	31.09	2.99	31.31	3.30	0.147	0.932
MAFB	23.22	1.61	22.91	1.62	22.86	1.59	23.27	2.03	0.313	0.816
LAFB	26.43	1.79	27.21	2.18	27.24	2.34	27.54	2.13	0.391	0.759
Wt(g)	15.85	1.23	16.07	1.53	15.98	1.51	16.30	1.93	0.207	0.891
Vol(ml)	13.29	1.25	13.68	1.45	13.42	1.28	14.00	1.73	0.922	0.431
SG	1.19	0.04	1.18	0.04	1.19	0.04	1.16	0.03	2.810	**0.041**

MAXH = maximum height; MAXB = maximum breadth; MAXT = maximum thickness; HAF = height of articular facet; MAFB = medial articular facet breadth; LAFB = lateral articular facet breadth; Wt = weight; Vol = volume; SG = specific gravity

Table 3: Descriptive statistics of various measurements of patella in female (201) population of different age groups & statistical significance between two variables

Parameter	<18 Yrs (n=11)		18-40 Yrs (n=161)		40-60 Yrs (n=24)		>60 Yrs (n=5)		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	P
Right side										
MAXH	34.94	2.00	35.99	2.75	35.65	2.90	36.27	2.99	0.607	0.611
MAXB	35.42	2.74	36.24	3.07	35.71	2.84	36.21	2.52	0.425	0.735
MAXT	18.28	2.21	18.44	1.75	17.96	1.93	17.62	3.02	0.763	0.516
HAF	26.69	2.16	26.78	2.07	26.64	2.26	26.97	1.35	0.052	0.984
MAFB	20.28	1.44	20.68	1.07	20.70	1.27	20.96	1.64	0.569	0.636
LAFB	23.99	1.34	23.95	1.46	23.86	1.35	24.64	1.46	0.413	0.744
Wt(gms)	13.11	0.77	12.89	0.91	12.78	0.98	12.85	0.96	0.337	0.798
Vol(ml)	11.09	0.54	11.11	0.81	10.96	0.95	11.00	0.71	0.270	0.847
SG	1.18	0.04	1.17	0.09	1.19	0.13	1.17	0.03	0.344	0.794
Left Side										
MAXH	34.21	2.28	35.31	2.83	34.81	2.91	35.30	3.52	0.687	0.561
MAXB	35.05	2.96	35.97	3.40	35.37	3.08	36.19	2.86	0.470	0.704
MAXT	17.93	1.59	18.19	1.71	18.05	1.91	17.23	2.66	0.568	0.637
HAF	25.95	1.89	26.28	2.20	26.28	2.33	26.28	1.40	0.079	0.971
MAFB	19.89	1.84	20.43	1.23	20.44	1.49	20.23	1.91	0.635	0.593
LAFB	23.84	1.42	23.59	1.47	23.36	1.67	24.20	1.52	0.557	0.644
Wt(gms)	12.78	0.70	12.60	0.95	12.50	1.05	12.48	1.34	0.237	0.870
Vol(ml)	10.82	0.60	10.80	0.78	10.38	2.18	10.60	0.89	1.189	0.315
SG	1.18	0.04	1.17	0.05	1.16	0.05	1.18	0.04	0.385	0.764

MAXH = maximum height; MAXB = maximum breadth; MAXT = maximum thickness; HAF = height of articular facet; MAFB = medial articular facet breadth; LAFB = lateral articular facet breadth; Wt = weight; Vol = volume; SG = specific gravity

Table 1 shows age and gender wise comparison of samples obtained in two groups. Majority of samples, irrespective of gender were in the age group 18-40 years, however, proportion of samples in age group >40 years was higher in males (38.7%) as compared to females (14.4%). Statistically, this difference was significant (p<0.001).

Table 2 shows impact of Age (Males) (n=199). Among males, no significant differences in measurements across different age groups were observed on all the parameters except SG at both the sides which was seen to be higher in younger age group as compared to older age groups (p<0.05).i.e. age of unknown male subject can be determined as <18yrs or 18-40yrs or 40-60 yrs or >60yrs by measuring specific gravity of patella in accordance to the mean value and standard deviation (SD) given in Table 2.

Table 3 shows impact of Age (Females) (n=201). Among females too, statistically no significant difference in mean values of different parameters was observed among different age groups.

Discussion

The present study explored nine parameters of patella bone from both sides in males as well as in females. Out of 400 samples included in the study, a total of 199 (49.8%) were taken from male and 201 (50.2%) were obtained from females.

Among males, no significant difference in measurements across different age groups were observed on all the parameters except specific gravity (SG) at both the sides which was seen to be higher in younger age group as compared to older age groups ($p<0.05$)) i.e age of unknown male subject can be determined as <18yrs or 18-40yrs or 40-60 yrs or >60yrs by measuring specific gravity of patella in accordance to the mean value and standard deviation (SD) given in Table 2.

Among females too, statistically no significant difference in mean values of different parameters was observed among different age groups.

These evaluations suggested that, age has no significant impact on patellar dimensions except specific gravity in males which is consistent with the previous study.[13] Even the study done on morphological variations of patella for age determination is also vague and limited.[14]

To best of our knowledge, our study is the first of its kind where all the nine dimensions of the patella bone have been studied to see the impact of age on patellar osteometry. We have also explored specific gravity and volume of the patella bone along with the physical dimensions like length, breath, thickness etc. Second, our study was done on a larger sample of 400 subjects. Third, we have studied the dimensions of both the left and right patellar bones of same individual (total 800 patella bones) and thus provided an extensive insight on the dimensions on both sides. The present study does not include prepubertal subjects which is one of the limitations of the study.

Conclusion

As per the study findings, patella bone cannot be used for age estimation. So forensic experts, medical officers or physician (who perform autopsy) should always keep in mind about the above result especially if receiving the mutilated body for post-mortem examination so that other criteria of age estimation can be utilised.

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ORIGINAL ARTICLE

An autopsy-based correlation study about developing standards for estimation of stature in females from distance between two anterior superior iliac spines in Central India region, Madhya Pradesh

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Abstract
Stature is the vertical distance between the top of vertex and the heel of the feet. Stature is one of the important parameters for establishing the identity of unknown corpse. Sometimes, the identification becomes very hard if the body is destroyed or mutilated in fire, explosions, murders, natural mass disasters like earthquakes, tsunamis, cyclones, floods and many others. In these situations, the need of forensic expert arises for establishing the identity of an individual from the amputated, mutilated and decomposed body fragments. Hence the aim of present study was developing standards for estimation of stature in females from distance between two anterior superior iliac spines in central India Region, Madhya Pradesh belonging to the age group of 20-60 years in the department of Forensic Medicine & Toxicology, M.G.M. Medical College and M.Y. Hospital, Indore (M.P). Among 258 females, the mean stature was 158.87±5.27, whereas the mean percutaneous inter anterior superior iliac spinous distance was found to be 22.02±1.36. Regression equation with significant correlation was derived. Multiplication factor for percutaneous inter anterior superior iliac spine was found to be 7.21. Even though stature can be calculated with the long bones of upper limbs and lower limbs but intact long bone may not be present all the time or only part of torso or pelvis is brought for autopsy, in this situation inter spinous distance can be used to estimate stature.

Keywords
Stature; Identification; Percutaneous inter anterior superior iliac spinous distance

Introduction

Forensic anthropology represents the application of knowledge and techniques of physical anthropology to solve the problems related to medicolegal jurisprudence.[1] The ultimate goal of using anthropometry in forensic medicine/science is to help the law enforcement agencies in accomplishing the 'personal identity' in case of unknown corpse.

Identification means determination of the individuality of a person in both living and dead and also in civil cases like marriage, inheritance of property, to get passport, to claim insurance, disputed sex etc. and criminal cases like identification of the victim and accused in sexual offences, murder and assault, during interchange of newborn babies, in decomposed, mutilated and skeletonized bodies etc. Identification may be complete (absolute) or incomplete (partial). Complete Identification means when person is known by his name with complete address and partial identification based on other details like age, sex, race and stature.[2] Identification of dead body and proof of "corpus delicti" is an essential & integral part of any criminal and civil justice delivery system throughout the world. The main purpose of corpus delicti (i.e. body of the victim and the essence of crime) is to establish the identity of the dead body, and infliction of violence in a particular way, at a particular time and place, by the person or persons charged with crime and none other.[3]

Human height is the vertical distance measured from the lowest point of the feet to the top most point of the head in standing or erect position.[4] Estimation of stature of a man or woman from the skeletal material or from the mutilated or amputated limbs or parts of limbs plays a conspicuous role in facilitating personal identification in incident of Homicide, accidents or natural disasters. Stature varies with genetics of a person, race, geographical location, environment and climatic conditions.[5] It has also been emphasized that relationships of different body parameters vary from population to population due to variation in their physical activity and nutrition.[6]

Stature can be estimated by developing correlation between supine length and percutaneous measurements of different body parts such as length of long bones of upper and lower limbs, inter-spinous distance, length of hand and foot etc. of the deceased. Height, like other phenotypic traits shows inter-racial and inter-geographical variation in measurements and their correlation with stature. Therefore, different nomograms have come out to be as a necessity for different population groups around the world.[7] Body length increases after death by about 2 cm because of loss of muscle tone, relaxation of joints and inter

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vertebral discs tension. Stature increases during morning and decreases during the course of afternoon and evening by 1.5-2.0 cm.[2]

Various studies have been conducted on the Estimation of stature from Percutaneous measurements of various body parts including hand,[8] forearm,[9] arm,[10] foot,[11] index & ring finger[12] etc. These studies are usually conducted on the basis of various measurements of different body parts and the height of the person by using scientifically derived formula such as multiplication factors and regression equations and then correlating them.

Materials and Methods

The present study was conducted in the Department of Forensic Medicine and Toxicology during the period of 01 year from July 2019 to June 2020. This was an analytic cross-sectional study which included total of 258 deceased female individual of an age group of 20-60 years. In the study population, the subjects included were irrespective of caste, religion, dietary habits and socioeconomic status. The units for measurement include Height in centimetres and Percutaneous inter Anterior Superior Iliac Spinous distance in centimetres to the nearest millimetres.

After giving detailed information to relatives of the subjects regarding the study, written informed consent was taken prior to the research. Detailed individual demographic data including the height, sex, age etc. were also recorded on the predesigned proforma. Anthropometric measurements of percutaneous inter anterior superior iliac spinous distance and Stature of each individual was taken. All the measurements were taken in a well-lighted room.

All the cases with surgically operated hip bone/pelvis and lower limb bones or with amputated lower limbs, cases with physical deformity, disease (e.g., fracture, dislocations, poliomyelitis, osteoporosis, rickets, scoliosis and kypho-scoliosis etc.) or defect affecting the growth in general or of bones, cases either suffering from gigantism or dwarfism, mutilated and decomposed body, those who are not the native of Madhya Pradesh and are of age below 20 years and above 60 years were excluded from the study. All the measurements were taken after manual removal of rigor mortis. Stature: It is measured as the vertical distance between the top of vertex and the heel of the feet in mid-sagittal plane, where the vertex is the highest point on the head when the head is held in Frankfurt Horizontal (FH) plane.[13] Stature was measured using the standard measuring tape in centimetres, which was held vertically in front of the subject in mid sagittal plane. Precautions were taken not to exert pressure as that may affect the contact measurement. The measurements were taken on autopsy table. Percutaneous inter anterior superior iliac spinous distance: Straight Percutaneous distance between the two anterior superior iliac spines (ASIS). It is an important landmark of surface anatomy which is at the anterior extremity of the iliac crest of the pelvis by using a standard measuring instrument (Vernier Caliper).[14, 15] (Position: - Supine) Bony distance between anterior superior iliac spine was found same as percutaneous distance if vernier caliper is being used for measurements.

After collecting all data, statistical analysis was carried out using IBM SPSS Statistics (IBM, current version 2015-statistical package for the social sciences) software package to calculate linear regression equations and compute multiplication factor. Multiplication factors for percutaneous inter anterior superior iliac spinous distance dimensions were calculated by dividing the stature of an individual by percutaneous inter anterior superior iliac spinous distance for each female subjects. The mean values & standard deviation (SD) of percutaneous inter anterior superior iliac spinous distance were calculated. Pearson's correlation coefficient was calculated to establish the correlation between the stature and percutaneous inter anterior superior iliac spinous distance dimensions. The significance of results was tested using Student's t-test. Correlation between two parametric variables was calculated using Pearson Coefficient of Correlation 'r' value. P value was used for testing statistical hypothesis. P-value of less than 0.05 was considered as significant and less than 0.001 as highly significant.

Results

During the study period of 01year from July 2019 to June 2020, we studied 258 deceased female individuals brought to the mortuary of the department of Forensic Medicine and Toxicology. Table 1 shows age wise distribution of the female subjects. In this study maximum number of cases were belongs to the age group of 20-25 years (13.95%) followed by 31-35 years (13.18%) and minimum number of cases were in age groups of 41-45 and 56-60 years that is 11.63%. In this study mean age of the female subjects was found to be 40.38 ± 12.07 years. Table 2 shows mean stature in female subjects was 158.84 ± 5.27 cm. In this study maximum height measured was 170.0 cm while, minimum height was 144.5 cm.

Table 3 shows mean percutaneous inter anterior superior iliac spinous distance (PIASIS) in female subjects was 22.02 ± 1.36 cm. In this study maximum PIASIS measured was 25.2 cm while, minimum PIASIS was 19.0 cm. The range of PIASIS in female subjects was from 19.0 to 25.2 cm. Table 4 shows that the correlation coefficient(r) between percutaneous inter anterior superior iliac spinous distance (PIASIS) and stature was 0.83 and P value was <0.001 indicates strong, positive and statistically significant correlation between PIASIS and stature. Table 5 shows that the multiplication factor and regression

equation derived for estimation of stature from percutaneous inter anterior superior iliac spinous distance in female study subjects. The mean Multiplication factor = Mean Stature /Mean PIASIS i.e. 7.21 for female study subjects in our study. The regression equation derived was 88.05+ 3.21 x PIASIS.

Table 1: Age wise distribution of female subjects

Age (years)	N	Percentage (%)
20 -25	36	13.95%
26 -30	32	12.40%
31 -35	34	13.18%
36 -40	32	12.40%
41 -45	30	11.63%
46 -50	31	12.01%
51 -55	33	12.79%
56 -60	30	11.63%
Total	258	100

Table 2: Distribution of height among female study subjects

Variable	Mean	Standard Deviation	Max	Min	Range
Height (cm)	158.87	5.27	170	144.5	144.5-170

Table 3: Distribution of anthropometric parameters for percutaneous inter anterior superior iliac spinous distance (PIASIS) in female subjects

Variable	Mean	Standard Deviation	Max	Min	Range
PIASIS (cm)	22.02	1.36	25.2	19	19-25.2

PIASIS- Percutaneous inter anterior superior iliac spinous distance

Table 4: Correlation between different variables in female subjects

Variable	R	Sig.
Correlation between PIASIS & Height	0.83	P<0.001

PIASIS- Percutaneous inter anterior superior iliac spinous distance

Table 5: Multiplication factor and regression equation for estimation of stature from Percutaneous inter anterior superior iliac spinous distance in female study subject

Variable	In female subjects
Multiplication Factor	7.21
Regression equation	88.05+ 3.21 x PIASIS

(x) Indicates multiplication

Table 6: Comparison between Mean stature, Mean Percutaneous inter anterior superior iliac spinous distance and Regression equation in female subjects with other studies

Parameter	Nachiket et al[14] (mean±SD)	Viral N. Chauhan et al[15] (mean±SD)	Present study (mean±SD)
Stature (cm)	156.70±6.24	154.65±9.50	158.87 ± 5.27
PIASIS (cm)	21.42±1.93	20.49±1.47	22.02 ± 1.36
Regression model	S = 148.909 + 1.074 x IASIS	S = 51.116 + 5.182 x IASIS	S = 112.16 + 2.40 x IASIS

Discussion

In the present study the mean stature of female subjects was found to be 158.87 ± 5.27, which was slightly higher than the study done by Viral N. Chauhan et al[15] on normal healthy female volunteers from Rajkot, Gujarat (154.65 ± 9.50) & S. Nachiket et al.[14] on South Indians normal healthy female subjects and students (156.7 ± 6.24) (Table 6). The stature is determined by several factors which include genetic, race, geographical location and environmental factors. Food habits, working pattern and physical activity are other determinants of stature. This is the reason for wide variations in mean stature amongst individuals of same sex belonging to different population groups around the world.

In the present study mean percutaneous inter anterior superior iliac spinous distance in females was found to be on higher side as compared to results of Nachiket et al.[14] and Chauhan et al.[15] (Table 6) The multiplication factor in present study for female was 7.21, which was lower as compared to the multiplication factor in the study done by Chauhan et al.[15] i.e., 7.570. This variation was due to the climatic condition and dietary habits vary considerably in different regions, along with racial and ethnical variation. This suggests that, the research studies conducted by residents of one state are not necessarily applicable to residents of another state.[16] Socioeconomic condition of our population has improved over the years, resulting in increment in height and consequently relationship between height and length of long bones is also changed. Hence, fresh formulae are needed for present generation.[17, 18]

In the present study regression equation for estimation of stature in females for percutaneous inter anterior superior iliac Spinous distance was 88.05+ 3.21x IASIS. The regression equations derived in the present study showed a different pattern compared to other studies.[14, 15, 19] This indicates the variations in the regression equations in different ethnic groups in India. So, regression equations of the present study cannot be applied to other population groups. Regression formulae and multiplication formulae (M.F.) on population need to be revised at least once in a decade to have greater accuracy in the prediction of stature among the living population.[20]

Conclusion

The anthropometric measurements of percutaneous inter anterior superior iliac spinous distance and height was taken by using "standard anthropometric measuring instruments" in centimetres. The data were recorded carefully up to mm for accuracy and then analyzed with associated factors and appropriate tests were applied to test the statistical significance. P value of <0.05 was considered as statistically significant for interpretation of findings. On the basis of present study following conclusions were derived:

1. In the present study the statistical significance between the correlations of percutaneous inter anterior superior iliac spinous distance and stature in females were established.
2. The multiplication factor is a handy tool and proves vital in situations where the forensic investigator is not well versed with complex mathematical equations or where the investigator is dealing with number of cases like mass disasters or people affected in terrorist attacks etc. Multiplication factors derived in the present study in females were found to be slightly lower as compared to previous study,[15] but linear regression equations were statistically superior and more reliable than multiplication factors for estimation of stature.
3. The regression equations derived in this study have lead to the conclusion that stature of an individual can be estimated precisely from percutaneous inter anterior superior iliac spinous distance parameters even when other details are not known to the investigating doctor, thus aiding in the process of identification especially in unknown cases.
4. Anthropometric measurements (stature and built) differ in different sexes and ethnic groups due to demographic factors which are strongly influenced by genetic and environmental factors, suggesting the need for different normograms for each endogamous group. Hence, the current study performed is of higher significance in the region where it is performed.
5. These types of studies have medico legal importance, as these studies helps forensic experts and anthropologists in establishing the identity of the person, where stature remains one of the primary characteristics of identification. These studies also help in understanding the similarities and differences that persist in a diverse population.
6. The results of the present study can be used as baseline information for population based studies in Madhya Pradesh region of India, So that anthropologists, forensic and other medico-legal experts can estimate the stature of the female individual of this part of India by the use of percutaneous inter anterior superior iliac spinous distance within the standard error of estimate. One must consider differences between populations to apply such formulae to other populations.

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ORIGINAL ARTICLE

Estimation of stature from percutaneous length of ulna in rural government medical college and hospital in Marathwada region of central Maharashtra

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Abstract
Establishing the identity of person is one of important procedure in Forensic investigation. In disasters settings, establishing the biological identity of an unknown body is quite challenging because of several extrinsic and intrinsic factors. For the forensic investigators and medico legal personals, it becomes difficult when a disaster occurs at when mixed populations are present at that time. The biological factor like the putrefaction, advanced decomposition, mutilated and commingled body parts or dismembered body parts makes individual identity difficult. Stature is one of the important components. India is multiethnic country, the populations of one geographic region varies in terms of our biological and cultural identity with other geographic. Due to the unavailability of population specific regression equations there is a need of develop population specific regressions equations so that it will help the medico legal fraternity while dealing with the unknown body. In the present study an effort has been made to study correlation between stature and percutaneous length of ulna using appropriate statistical methods. The present cross-sectional study consisted of 240 medical students (male-110, female-130) between the age group of 19-23 year at SRTR Government Medical College, Ambajogai, Dist. Beed, Maharashtra, India. We measured stature and percutaneous length of ulna of study subjects with the help of stadiometer and sliding vernier caliper. The mean length of right ulna (cm) in males was 25.98 ± 1.24 and 22.01 ± 1.33 in females. The mean length of left ulna (cm) in males was 25.63 ± 1.28 and in females was 21.84 ± 1.72. The Standard error for male and female was 4.21 and 4.56 respectively. The correlation coefficient (r) for male and female was 0.62 and 0.69 respectively. Intercept for males was 89.35 and for females it was 110.44.The linear regression equation for males was found to be Y = 3.11 X + 89.35 and for females it was Y = 2.40 X + 110.44, where X: percutaneous ulnar length (cm) and Y: Stature (cm). Stature and percutaneous length of ulna of both the hands shows positive strong correlation so that forensic experts can estimate the stature with the help of percutaneous length of ulna. Since sample size is small, we can't generalize it to larger population. More extensive studies have to be undertaken in future.

Keywords
Identification; Forensic Anthropology; Percutaneous ulnar length; Stature

Introduction

Identification is one of the important task in medicolegal practice.. Personal identification denotes determination of individuality of a person. It may be complete (absolute) or incomplete (partial). Complete identification signifies absolute fixation of individuality of a person. Partial identification implies ascertainment of only some facts about the identity of the person while other still remain unknown. Age, sex and height are the prime characteristics of identification.[1] The stature is considered as one of the important parameters of personal identification. In absence of well documented skeletal data in Marathwada region, the researcher has transferred their attention toward living groups of Indian population and has taken relevant bone lengths over the skin and correlated them with the height to find out the degree of association between them and subsequently estimated multiplication factors and regression formulae from long bones for reconstruction of stature. Assessing the height of an individual from measurements of different parts of human body has always been of immense interest to the anatomists, anthropologists and forensic science experts.[2,3]

In a vast and multi-ethnic country like India, body proportions vary from population to population. It is, therefore, no longer new to anatomist and physical anthropologists that, various body parts exhibit a close relationship with stature as such regression equations developed in relation to stature is handily used within the identification of victims of mass disaster wherever fractional body components commingled; in addition as in social anthropology within the determination of a particular tribe's antecedence based on their identifying features.[4,5] Consequently, formulae developed for population of one region may not necessarily be applicable on population of another region due to diversity of population.[6] An appropriate guide for selection of an equation for evaluation of height could

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be used by the measurement of length of long bones such as femur, tibia, fibula and ulna.[7-9]Femur being the biggest and strongest bone in the body it is the best bone to derive an equation for evaluation of height. The ulna has simply recognizable surface landmarks that make the measurements achievable; therefore, it can indirectly be used to formulate the stature.[10,11]The length of forearm bones like ulna gives more accuracy in devising regression equation of height and precisely predicts height.[12]Also, ulna is usually hypodermic throughout its length and effortlessly approachable for accurate measurements, therefore, it had been selected for this study. Ossification of the ulna starts at 8th fetal week, and the proximal epiphysis fuses with the shaft in the 14th year in females and 16th year in males. The distal epiphysis unites with the shaft in the 17th year in females and 18th year in males.

Hence, this study was done on medical students aged between 19-23 years. We felt a need to form a regression equation for our population of this area. With this view we conducted this study to predict stature on the basis of per-cutaneous lengths of ulna of the population in this area i.e., central region of Maharashtra (Marathwada region)

Material and Methods

The present cross-sectional study consisted of 240 medical students between the age group of 19-23 years of SRTR Government Medical College, Ambajogai, Dist. Beed, Maharashtra, India. The study was conducted in SRTR, Government Medical College, Ambajogai, Dist. Beed, Maharashtra, India. Institutional ethical clearance was obtained. The objectives and the methods of the study was explained to the sample population, and informed written consent was obtained, and informing that the study was totally voluntary and they could refuse to take part in the study without facing any disadvantage (Ethics committee approval number – S.R.T.R.G.M.C./Pharma/IEC/Out word No. 17(A) Date: 23/04/2018). All the measurements were taken in a reasonably well-lit room, at a fixed time between 9.00 a.m. to 12.00.p.m. to eliminate diurnal variation. It was measured and recorded only by corresponding author, to avoid inter observer error. Participants with injuries that may affect stature and/or percutaneous Length of Ulna, with deformities in any of the hands or spine, congenitally malformed limbs, metabolic disorders, abnormal gait, loco-motor disability were excluded from the study along with non-consenting students. Following measurements were taken

Stature: It was measured as vertical distance from the vertex to the floor. Measurement was taken by making the subject to stand erect on a horizontal resisting plane, bare footed with shoulder blocks and buttocks touching the wall. Palms of hand were turned inwards and fingers horizontally pointing downwards. Stadiometer was placed in straight vertical position in front of the subject with head oriented in Frankfurt Plane (eye-ear-eye plane). The movable rod of the Stadiometer is brought in contact with vertex in the mid sagittal plane (Fig. 1).

Percutaneous Length of Ulna: For measuring the ulnar length the subjects were made to sit. Then their forearms were placed on the table flexed 90^0 at the elbow. The straight distance between the most proximal bony points between olecranon process of ulna to the most distal bony point of the styloid process of ulna in the supinated forearm was taken as length of ulna using sliding vernier calliper**.** To avoid any sort of variation in measurements all the subjects were observed by the same observer during taking bony length and also they used same instrument to avoid any technical or inter-observer error and to maintain accuracy. The height and length of ulna was taken at same time and expressed in centimetres (Fig. 2). Percutaneous Ulna length was measured on both sides using a vernier calliper. All measurements were taken by the corresponding author to eliminate observer bias.

The data was analysed using the statistical analysis package of SPSS version 21 to derive a linear regression equation for stature estimation from percutaneous ulnar length of male for male and female. For regression analysis, the dependent variable was taken as the body length while the independent variable was percutaneous ulna length. Standard error of estimate and 95% confidence interval for regression was computed. P- value of <0.05 was considered as significant.

Results

In present study, out of total 240 medical female students formed 54% of study and males formed 46% of the study. The male: female proportion was 1:1.2 in this study. The mean height (cm) in male was 168.21±8.86 SD and in female it was 156.45±4.11 SD. The mean length of right ulna (cm) in males was 25.98±1.24 and in females it was 22.01±1.33. The mean length of left ulna (cm) in males was 25.63±1.28 and in females was 21.84±1.72 in this study (Table 1). Table 2 shows regression analysis between stature and ulnar length in both genders. The Standard error for male and female was 4.21 and 4.56 respectively. The correlation coefficient (r) for male and female was 0.62 and 0.69 respectively. Intercept for males was 89.35 and for females it was 110.44. The linear regression equation for males was found to be $Y = 3.11 X + 89.35$ and for females it was $Y = 2.40 X + 110.44$. Stature and percutaneous length of ulna of both the hands shows positive strong correlation.

Figure 1: Measurement of stature

Figure 2: Measurement of percutaneous length of ulna

Table 1: Height and ulnar parameters in gender

Parameter	Mean ± SD	
	Male (n=110)	Female (n=130)
Height(cm)	168.21±8.86	156.45±4.11
Length of right ulna(cm)	25.98±1.24	22.01±1.33
Length of left ulna(cm)	25.63±1.28	21.84±1.72

Table 2: Regression analysis between stature and ulnar length in both genders

Variables	Gender	
	Male	Female
Linear regression equation (Average)	Y = 3.11X + 89.35	Y = 2.40 X + 110.44
Standard error	4.21	4.56
Correlation coefficient (r)	0.62	0.69
p value	<0.001	<0.001
X: Percutaneous ulnar length (cm), Y: Stature (cm)		

Table 3: Comparison of present study with other studies from Maharashtra

Study	Year	n	Population	Region	Age (years)	Stature with percutaneous length of ulna comparison	
Bamne et al. [14]	2015	200	Individuals	Maharashtra	20-25	Right	Left
						Y=70.75+3.46 X	Y=102.82+2.21X
Anjali et al. [18]	2016	200	Medical students	Rural Maharashtra	18-28	Male	Female
						Y=93.45 + 2.92X	Y=113.89+2.37X
Inamdar et al.[13]	2018	300	Medical students	Maharashtra	18-24	Male	Female
						Y=90.14+3.04 4X	Y=112.1+2.455 X
Present study	2019	240	Medical students	Rural Maharashtra	19-23	Male	Female
						Y=3.11X+89.3 5	Y=2.40X+110.44

Discussion

The estimation of stature/ height is of very important whenever human bodies are found in mutilated forms or even when only skeletal remains are available for identification of individual. Estimation of stature is considered to be an important assessment in the identification of known or unknown human bodies. Stature can be affected by many factors and diseases like – Nutrition, Hormonal Disorders like Turners syndrome and Kline filters syndrome, Gigantism, Dwarfism, etc. Stature is less in afternoon and evening due to the reduced elasticity of the intervertebral discs and the longitudinal vertebral muscles. The stature is greater by 1-3 cm on lying. On an average, the body lengthens after death by about 2 cm due to complete loss of muscle tone, relaxation of large joints and loss of tensioning effect of Para spinal muscles on intervertebral discs.

In present study, out of total 240 medical students females formed 54% of study and males formed 46% of the study. The male: female proportion was found to be taken 1:1.2 in this study. In this study the mean height (cm) in male was

168.21±8.86 SD and in female it was 156.45±4.11 SD. The mean length of right ulna (cm) in males was 25.98±1.24 and in females it was 22.01±1.33. The mean length of left ulna (cm) in males was 25.63±1.28 and in females was 21.84±1.72 in this study. Vaishali Inamdaret al[13] had similar regression equation in a study done in Marathwada region, their study findings were in accordance with our study.

So findings of the present study are in accordance with other researches which demands to have separate equation for different regions and races across the world (Table 3). The limitation of this study was smaller sample size and cross-sectional nature of this study which limits us to generalize these findings in general population.

Conclusion

The present study finds a positive correlation between the stature and the percutaneous ulnar length. We also established the regression equation. If either height of a person or percutaneous length of Ulna bone is known us the other parameter can be calculated and this would be very much useful for forensic experts for fixing identity of individual. This was a cross sectional study on sample from particular geographic region, so we cannot generalize findings to population.

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

Conflict of interest: None to declare

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ORIGINAL ARTICLE

Steele and McKern's indirect method of estimating maximum femur length in an indigenous population of East Godavari district in Andhra Pradesh of Southern India – A validation study

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Abstract

Femur is the best choice for estimating stature of an individual. Robust mathematical equations were developed by many researchers for estimating stature from total length of femur. Though these equations are readily available, they are population specific and require an entire intact femur bone. In our present study we tried to address these two questions by trying to develop population specific equations from fragmentary femur bones. The objective of the study is to find correlation between fragments of femur with maximum length of femur and develop simple and multiple equations for estimating maximum length of femur from femur fragments. The various segmental measurements of femur are selected as suggested by Steel and McKern. We studied 100 femur bones of both sides as a part of validation study before initiating large scale research on a larger study sample. The results were promising with positive correlations between fragments and total length of femur and the regression equations developed showed statistical significance at $p<0.05$.

Keywords

Steel and McKern's method; Maximum femur length; Correlation; Regression equations

Introduction

Stature of an individual being one of the primary identification features along with age and sex, has paramount importance in the identification profile of an individual. Though stature estimation is pretty straight forward in a living individual and an intact dead body, it is not always the case. Investigating authorities recover mutilated bodies and skeletonized bones and seek forensic physician's help in identifying the remains. They try to seek answers to the questions as to what could be the stature of the person? what could be the approximate age? And what is the sex of the person? before moving on to further investigation. In the absence of complete skeleton, the forensic anthropologists have to rely on the indirect method for estimating stature. The indirect method or the mathematical method utilizes regression formulae developed on a particular population for determination of stature from individual bone measurements. Long bones of adult human beings are known for their reliability for stature estimation and Femur is the best bone for this task. Many researchers across the globe have worked on stature estimation from femur length and came up with robust equations which are highly reliable. Though there are numerous studies in this area, the major limitation is the necessity of an intact femur.[1-3] It is not always an intact femur will be available. We tried to address this issue by attempting to derive equations for estimation of length of femur from its segmental fragments by application of Steele and McKern method. 4 Steele and McKern segmentation of adult femur is used to derive simple and multiple regression equations in the native south Indian population. These equations can be used to reconstruct the femur length and there by utilized for stature estimation with the already existing population specific equations from total femur length. The present study being first of its kind on the native population of East Godavari district of Andhra Pradesh in southern India, a validation study is conducted. The objectives of the study are to find correlations between various Steele and McKern segmental measurements and MFL in a native population of East Godavari district in Southern India, and to develop simple and multiple regression equations for estimating MFL from Steele and McKern segmental measurements in the study population.

Materials and Methods

The Department of Forensic medicine & Toxicology of Rangaraya Medical College in East Godavari District of Andhra Pradesh in Southern India, the premier medical college is catering its medico-legal services to the entire east Godavari district for the past 75 years. The various bones received by the dept over a period of time were selected and 100 such adult dry femora of right and left side were studied after obtaining approval from Institutional Ethics Committee.Only bones whose identity was established as to belonging to the specific study population were included in the study. Fractured bones

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and bones with pathological conditions were excluded from the study.

Five landmarks suggested by Steele and McKern4 were selected and marked on the femur bone and include

(1) The most proximal point of the head of the femur
(2) The mid-point of the lesser trochanter
(3) The most proximal extension of the popliteal surface at the point where the medial and lateral supracondylar lines become parallel below the linea aspera
(4) The most proximal point of the intercondylar fossa
(5) The most distal point of the medial condyle

These five landmarks divide femur into four segments (S1 to S4).The various segmental measurements utilized in this study are as follows

Segment 1 (S1): Distance between landmark 1 and 2 i.e., the distance between the proximal point of the head of the femur and the mid-point of the lesser trochanter.

Segment 2 (S2): Distance between landmark 2 and 3 i.e., the distance between the mid-point of the lesser trochanter and the most proximal extension of the popliteal surface at the point where the medial and lateral supracondylar lines become parallel below the linea aspera

Segment 3 (S3): Distance between landmark 3 and 4 i.e., the distance between the most proximal extension of the popliteal surface at the point where the medial and lateral supracondylar lines become parallel below the linea aspera and the most proximal point of the intercondylar fossa.

Segment 4 (S4): Distance between landmark 4 and 5 i.e., the distance between the most proximal point of the intercondylar fossa; and the most distal point of the medial condyle.

Maximum Femur Length (MFL):Linear distance between the most superior part of the head of the femur and the most inferior part of the medial condyle.

Hepburn type of osteometric board is used to measure the maximum length of the bones. Vernier calipers is usedfor taking segmental measurements.All measurements were in centimeters. Data collected is analyzed with SPSS statistical software 17. Correlations were calculated between segments and MFL and Simple and multiple regression equations are derived.

Results

The mean maximum length of femur is 44.03 cm. Segments 1 to 4 had a mean measurement of 6.88, 21.20, 12.06, and 3.88 cm respectively (Table 1). Pearson correlation between maximum length of femur and various segments are shown in Table 2. It is evident that all segments have a statistically significant positive correlation with total length of femur ($p<0.000$). Simple regression equations along with standard error of estimates are shown in Table 4. All four equations derived from four segments show a statistical significance ($p<0.000$). Multiple regression equations along with standard error of estimates are shown in Table 5 & Table 6. The various segmental measurement variables used by Steele and McKern to derive the multiple regression equations in their study are limited to seven. 4 However, in our study we tried various combinations between segments and derived 11 equations. All eleven equations showed high correlations and are statistically significant ($p<0.000$).

Table 1: Descriptive statistics of various segmental measurements of femur bone

	n	Mean	Standard Deviation
Maximum Length	100	44.0320	2.85685
Segment 1	100	6.8830	.62281
Segment 2	100	21.2040	1.81235
Segment 3	100	12.0620	1.41734
Segment 4	100	3.8800	.51522

Table 2: Correlation between various segments of femur bone

		Length	Seg1	Seg2	Seg3	Seg4
Length	Pearson Correlation	1	.715*	.725*	.531*	.659*
	Sig. (2-tailed)		<0.001	<0.001	<0.001	<0.001

Table 3: Comparison of correlation coefficients with other studies

Segment	Correlation Coefficient (R)	
	Other studies	Present study
Segment 1	Jacobs (1992), R=0.758 Wright and Vásquez (2003), R= 0.380 Mendonca (2000), R= 0.62	R= 0.715
Segment 2	Wright and Vásquez (2003), R = 0.29	R= 0.725
Segment 3	Wright and Vásquez (2003), R = 0.52 Ghosh, Konar, Mondal et al. (2015), R= 0.81	R= 0.53
Segment 4	Wright and Vásquez (2003), R= 0.31 Jacobs (1992), R=0.134	R= 0.659

Table 4: Simple Regression models

Segment	R	R^2	Equation	SEE
S1	0.715	0.512	21.451 + 3.281 (S1)	2.006
S2	0.725	0.525	19.803 + 1.143 (S2)	1.978
S3	0.531	0.281	31.134 + 1.069 (S3)	2.434
S4	0.659	0.435	29.846 + 3.656 (S4)	2.158

SEE = standard error of estimate

Table 5: Multiple regression models with two segments

Segment	R	R^2	Equation	SEE
S1, S2	0.863	0.745	10.403+2.336(S1) + 0.828(S2)	1.457
S1, S3	0.787	0.620	16.361+2.800(S1) + 0.696(S3)	1.779
S1, S4	0.785	0.617	19.730+2.326(S1) + 2.138(S4)	1.786
S2, S3	0.957	0.916	1.909+1.265(S2) + 1.269(S3)	0.838
S2, S4	0.837	0.700	15.756+0.876(S2) + 2.5(S4)	1.580
S3, S4	0.763	0.582	22.288+0.796(S3) + 3.13(S4)	1.866

SEE = standard error of estimate

Table 6: Multiple regression models with three segments

Segment	R	R^2	Equation	SEE
S1, S2, S3	0.988	0.977	– 0.507+1.334(S1) + 1.065(S2) + 1.059(S3)	0.444
S1, S2, S4	0.893	0.797	10.291+1.746(S1) + 0.744(S2) + 1.535(S4)	1.307
S1, S3, S4	0.841	0.707	15.229+1.971(S1) + 0.636(S2) + 1.949(S4)	1.571
S2, S3, S4	0.985	0.971	1.721+1.092(S2) + 1.112(S3) + 1.48(S4)	0.495

SEE = standard error of estimate

Discussion

In the present study, five variables (MFL. Seg1, Seg2, Seg3 and Seg4) were selected and measured from 100 adult dry femora and analysed. The mean total length of femur is 44.03 cm (SD=2.865). Similar mean measurement of femur length was found in a study conducted by Chandran and Kumar on South Indian population in Chennai.1 The mean total length of femur in Steele and McKern study is 44.90 cm (SD=1.71) for males and 41.51 cm (SD=1.28) is slightly higher than our sample mean as people from Indian origin are shorter than the population sample considered by them and due to the geographic differences in skeletal development. 4 Though the results were similar, this is pure coincidence by chance. Due to vast racial differences between South Indians and Americans, this finding cannot be considered as significant.

The mean lengths of S1, S2, S3 and S4 are 6.88 cm (SD=0.622), 21.20 cm (1.812), 12.06 cm (SD= 1.417) and 3.88 cm (0.515) respectively. Steele and McKern calculated the mean segmental measurements and standard deviations of their sample of 101 femora, however presented their findings for males and females separately. An attempt to differentiate the sex of our sample was not done due to the absence of complete skeleton and any such attempt would be risky and compromise the robustness of regression equations derived. Pearson's Correlation coefficients were calculated and various segmental measurements had a positive and significant correlation with MFL. Segment 1 and Segment 2 have a strong positive correlation followed by Segment 4. Highest correlation is found between S2 and MFL (0.725), followed by S1 (0.715) and S4 (0.659). Segment 3 had a moderate positive correlation (0.531) (Table 2).

In our study the correlation coefficient for segment 1 is 0.715 with MFL. Slightly similar correlations were found in a study done by Jacobs (1992), R=0.758. The value of 'r' forsegment 1 ranged from 0.380 to 0.620 in two different studies by Wright and Vásquez (2003) and Mendonca (2000). [57] Wright and Vásquez (2003) in their study on American population found a low positive correlation, R= 0.29 between segment 2 and MFL. 6 However, Segment 2 in our study population showed strong correlation with MFL compared to other segments (R=0.73). Segment 1 of Wright and Vásquez (2003) study population showed better correlation compared to other segments (R=0.63) Segment 3 had a weak positive correlation with MFL (R= 0.53) in the native population studied. Similar results were observed by Wright and Vásquez in American population (R= 0.52). 6 A study on Bengali population of the state of West Bengal of India by Ghosh et al. (2015), found better positive correlation between S3 and MFL (R= 0.81). 8 Gidna and Domínguez-Rodrigo (2013) in their study on a Spanish population reported a correlation of 0.66 for males and 0.48 for females between S3 and MFL.9 No such differentiation between males and females was attempted in our study. Segment 4 of this study population showed moderate correlation (R= 0.659) better than S3 (R=0.531). However, a very weak correlation was found with MFL in the studies conducted by Wright and Vásquez (2003) (R= 0.31) and Jacobs (1992) (R= 0.134). [5,6]

The difference in the value of R could be explained by the racial difference in the study sample. Jacobs (1992) studied a European sample, Mendonca (2000) done the study on Portuguese population, Wright and Vásquez (2003) studied the Americans, Ghosh et al. (2015) studied Bengali population in India and Gidna and Domínguez-Rodrigo (2013) studied Spanish population (Table 3).[5-9] The moderate to high degree of positive correlations obtained in this study endorses the utility of Steele and McKern's segmental measurements of femur in the estimation of maximum length of femur by deriving regression equations.

Regression Equations

The model summary gives information regarding R, R^2, Adjusted R^2 and Standard error. The multiple correlation coefficient (R) indicates the level of correlation between various segmental measurements and MFL. A coefficient of determination value (R^2) indicates the percentage of variation of MLF is accounted to the particular segment or combination of segments of interest. The ANOVA test provides information

about the statistical significance and predicts whether the regression model developed is a good fit of data. All the regression equations derived are statistically significant ($p<0.000$). The unstandardized coefficients of MFL and Segmental measurements are calculated and simple and multiple regression equations are derived. Simple regression equations derived from each individual segment showed positive correlation. Proximal segments 1 and 2 showed strong correlation of 0.725 and 0.715 and segments 3 and 4 showed moderate positive correlation of 0.531 and 0.659 respectively with MFL. The standard error of estimates was also minimal (Table 4).

Multiple regression equations developed with two segments showed better positive correlation with MFL in the present study compared to single segments. The proximal segments 1 and 2 had a correlation of 0.863 with MFL and accounted for 74.5% of variation in length of femur ($R= 0.863$; $R^2 = 0.745$). Shaft segments, Seg2 and Seg3 showed a correlation of 0.957 and contributed to 91.6% of variability of MFL ($R= 0.957$; $R^2 = 0.916$). Distal femur segments (S3 S4) had a correlation of 0.763 and contributed to 58.2% of variation ($R= 0.763$; $R^2 = 0.582$). Other segmental combinations such as S1, S3; S1, S4 and S2, S4 were also tried to check for improvement of correlation and the values are 0.787, 0.785 and 0.837 respectively. It is observed that the equations developed with shaft segments had the best correlation ($R= 0.957$) (Table 5).

Regression equations utilizing three segments improved correlation. Segments involving proximal end and shaft (S1, S2 and S3) showed the best correlation of 0.988 and accounted for 98% of MFL variability. Segment 2, 3 and 4 showed similar correlation when combined ($R= 0.985$) and segments 1, 2 and 4 also showed a high correlation when combined ($R= 0.893$). The reason for these strong correlations can be attributed to Segment 2, as S2 has the best correlation of 0.725 individually with MFL in our study sample. Regression equations developed omitting segment 2 has brought the correlation to less than 0.85 (Table 6).

From these observations, it is evident that multiple regression equations with three segments have a better correlation of more than 0.98 with MFL and it is suggested that three segments should be used for estimating MFL and shaft segment S2 should be included in the estimation whenever available. In the event of availability of two segments, shaft segments (S2, S3) and proximal segments (S1, S2) should be used in the order mentioned. When MFL has to be estimated from one segment, S2 followed by S1, followed by S4 and S3 are better predictors.

Conclusion

Present study showed that various segmental measurements as suggested by Steele and McKernare positively correlated with maximum total length of femur in our study sample as well. Highest correlation was found for segment 2. Proximal segments (S1 and S2) are better correlated with MFL and all the segmental measurements had a linear and positive relationship. In medicolegal situations when fragments of femur are recovered, the regression formula using Segment 1 and Segment 2 will be most reliable due to high degree of correlation. With the help of regression equations, femoral length can be calculated from the segmental measurements; and then femoral length can be used to calculate the stature of the individual. The formulae developed are part of a pilot project andproved that Steele and McKern's method of calculating maximum length of femur from various segmental measurements is still applicable and has paved way for large-scale research for development of population specific equations in this region.

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

Conflict of interest: None to declare

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ORIGINAL ARTICLE

Accuracy and reproducibility of 3D data acquisition for human teeth using intra-oral scanners: A forensic odontological approach

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Abstract
Three-dimensional (3D) scanning technologies are a new development in the area of forensic dentistry. Dental measurements also called as odontometrics can provide forensic odontologist an effective and reliable approach to evaluate the age, sex and biogeographical ancestry. The present study aims to compare and evaluate the accuracy of the acquired 3D dental model through manual and digital linear measurements. Sixty-three extracted human teeth were used in the study. The manual metrics obtained using digital vernier caliper served as reference values, and the digital models of teeth were created using an intraoral 3D scanner and further measurements were recorded through 3D propriety software. A parametric two sample T-test showed statistical agreement among the four parameters for premolars and five parameters for molars out of seven total parameters. The work suggests digital technology may serve as an alternative technique over physical measuring techniques, but certain structured standards and procedures should be developed for data acquisition and analysis to address the discrepancies encountered by digitization of data.

Keywords
Odontometrics; 3D scanning; Digital measurements; Forensic odontology; Intra-oral scanners

Introduction

Dental measurements also referred to as odontometrics provide significant data for forensic dental and anthropological studies that offer details on dimension and proportions of the teeth and its parts. It is primarily used by forensic odontologists and dental anthropologists to determine sex, age and biogeographical ancestry.[1,2] With the advancement in imaging technologies, and incorporation of three-dimensional (3D) scanners, new dimensions have been introduced in the medical and dental fields.[3] In the mid-1980s, intraoral scanning devices were used in dentistry. In U.S. and Europe, intraoral scanners are extensively used for taking digital impressions.[4] The data acquired as a result of 3D scanning gives accurate information in terms of colour, form and shape in addition to detailed spatial information of biological structures when compared to conventional approach.[5-7]

3D dental model offers advantage over the conventional model such as easy accessibility, less storage space, longevity with no distortion over time, also enables the professional to share information across the globe and serve as a means for future reference.[8-10] Digital 3D dental models also allow measurements with the help of computer software.[11,12] These models can also be later printed using 3D printers that would aid in future analysis. However, their reliability depends on how accurate these models are to the original tooth specimen.[13] Within this context, owing to the growing usage of portable laser scanners in the area of forensics, determining the precision and quality of optical measurements is a significant concern for the future. Thus, the purpose of this study is to compare and evaluate the accuracy and reproducibility between manual and digital odontometrics.

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Materials and Methods

The study was conducted by using sixty-three extracted human teeth comprising of permanent maxillary first premolars, permanent maxillary second premolars, permanent mandibular first premolars, mandibular second premolars, permanent maxillary first molars, permanent maxillary second molars permanent mandibular first molars and permanent mandibular second molars collected from the local dentists and preserved at Laboratory of Forensic Odontology, National Forensic Sciences University (NFSU), Gujarat, India. Premolars and molars having intact anatomical crowns were only included for performing measurements. Any teeth with restoration or fracture, anomalies as well as third molars were excluded. Manual measuring method, based on the conventional odontometrics (Figure 1A) was performed by one observer which served as reference whereas digital metrics was accomplished using dedicated 3D intraoral scanner and software (Figure 1B).

Linear measurements of all the teeth at coronal and cervical (cementoenamel junction) levels were measured using a digital vernier calliper with an accuracy of 0.05mm. Seven linear measurements - total tooth length (TTL), crown length (CL),

root length (RL), mesio-distal diameter of crown (MD), bucco-lingual diameter of crown (BL), mesio-distal diameter of crown at cervix (MDCV), bucco-lingual diameter at cervix (BLCV)were included in this study. The parameters used in the study are the standard measurements used for various analytical procedures in forensics as well as for defining the anatomy of teeth.14 The parameters are defined as follows as per Tabasum et al.[14]

1. Crown length (CL): Maximum distance from the incisal edge to the cervical line
2. Root Length (RL): Maximum distance from the cervix at buccal aspect to the apex
3. Total Tooth Length (TTL): Crown length + Root Length
4. Mesio-distal Diameter of Crown (MD): The distance between two parallel planes tangential to the most mesial and most distal points of the crown
5. Mesio-distal Diameter of Crown at Cervix (MDCV): The distance between two parallel planes tangential to the most mesial and most distal points at cervix
6. Bucco-Lingual Diameter of Crown (BL):The maximum distance between two parallel planes, one tangential to the most lingual point of the crown and the other tangential to a the most buccal point on crown
7. Bucco-Lingual Diameter of Crown at cervix (BLCV) :The maximum distance between two parallel planes, one tangential to the most lingual point at cervix and the other tangential to a the most buccal point at cervix

For digital measurements, the teeth were scanned using Medit i500 Intra-oral hand-held laser scanner, post processed (removal of base, cleaning) in the medit software and eventually a 3D model was made. The blue light mode with a focal length of 17 mm and filter level 2.

Digital metrics on the 3D models (STL format) were performed using Geomagic Studio 13.0 software. The 3D model rotated and aligned in a straight plane after which based on the landmarks two points were selected to obtain measurements. To prevent observer bias, the conventional and digital measurements were taken by two independent observers. In order to determine the precision of the measurements, all measurements were repeated thrice, and the mean of the three measurements was used in the statistical analysis. The data was evaluated using R software, version 4.0 where descriptive analysis for the quantitative variables was conducted. A parametric two sample T- test was conducted to assess and measure the difference between the two approaches for each kind of tooth. The results were considered significant at $p < 0.05$.

Results

The data comprised of total 63 (n=63) extracted teeth out of which 36 were premolars (n=36) and 27 were molar (n=27). All the samples were subjected to conventional and digital measurements. In case of digital measurements, the mean, standard deviation and coefficient of variation were calculated for each parameter (Table 1) and (Table 2) summarizes the results of descriptive analysis.

For premolars, the following results were observed while comparing conventional and digital measurements: (Table 3)

- Statistically significant difference was observed between mesio-distal width (MD)($p=0.01$), bucco-lingual width (BL) ($p<0.001$) and bucco-lingual width at cervix (BLCV) ($p<0.001$).
- No significant difference was observed between conventional and digital measurements for tooth length, crown length, root length and mesio-distal width at cervix (MDCV).

For molars, following results were observed while comparing conventional and digital measurements: (Table 4)

- Statistically significant difference was observed between mesio-distal width at cervix (MDCV) ($p=0.002$) and bucco-lingual width (BL) ($p <0.001$).
- No significant difference was observed between conventional and digital measurements for tooth length, crown length, root length and mesio-distal width (MD) and bucco-lingual width at cervix (BLCV).

The graph (Figure 2) showed that the conventional and digital measurements were within the limits of agreement when measuring entire tooth length. However, some variations were observed in the graph while measuring the bucco-lingual and mesio-distal dimensions.

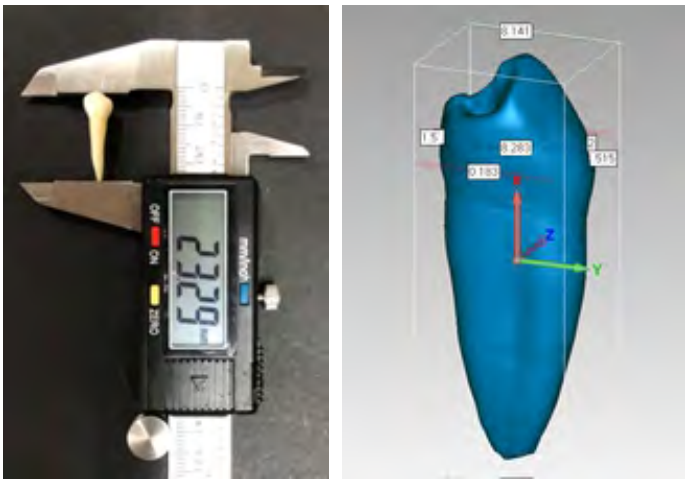

Figure 1: Linear measurements by conventional and digital technique

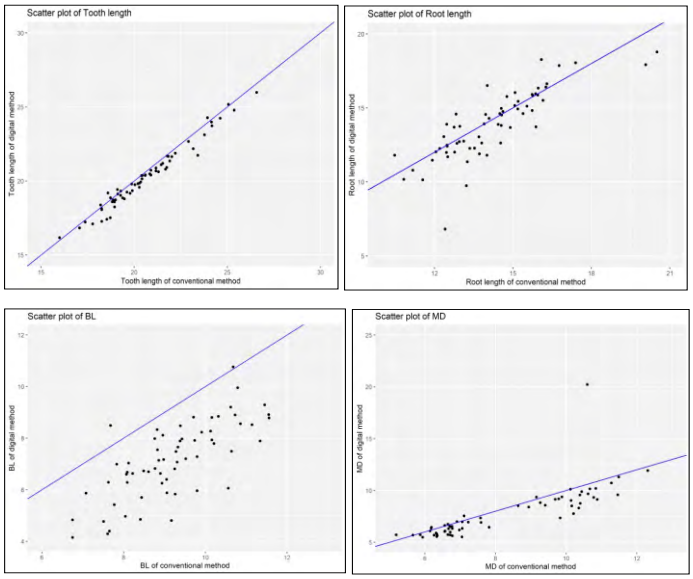

Figure 2: Scatter plot of conventional v/s digital technique

Table 1: Descriptive analysis of premolars using digital technique

Measurement	N	Mean	SD	Minimum	Maximum	Coefficient of variation (%)
Tooth length	36	21.256	2.078	18.250	26.580	9.778
Crown length	36	6.950	1.025	5.330	9.820	14.746
Root length	36	14.684	1.975	11.170	20.510	13.448
MD	36	6.719	0.820	5.190	10.400	12.211
BL	36	8.428	0.801	6.750	9.800	9.498
MDCV	36	4.893	0.897	3.850	9.560	18.329
BLCV	36	7.886	0.951	5.140	9.440	12.063

MD = Mesio-distal diameter of crown; BL = Bucco-lingual diameter of the crown; MDCV = Mesio-distal Diameter of Crown at Cervix; BLCV = Bucco-Lingual Diameter of Crown at cervix

Table 2: Descriptive analysis of molars using digital technique

Tooth Measurement	N	Mean	SD	Minimum	Maximum	Coefficient of variation (%)
Tooth length	27	19.747	2.036	15.990	25.370	10.309
Crown length	27	6.760	3.865	4.6201	25.650	57.174
Root length	27	13.591	1.667	0.480	17.400	12.262
MD	27	10.166	1.029	7.110	12.310	10.12
BL	27	10.242	0.818	8.820	11.560	57.987
MDCV	27	8.524	0.915	6.540	10.020	10.736
BLCV	27	9.684	1.247	7.470	11.570	12.882

MD = Mesio-distal diameter of crown; BL = Bucco-lingual diameter of the crown; MDCV = Mesio-distal Diameter of Crown at Cervix; BLCV = Bucco-Lingual Diameter of Crown at cervix

Table 3: Two Sample T-test results for premolar measurements

Parameter	Mean Difference	SE	95% LCL	95% UCL	p_value
Tooth Length	0.417	0.484	-0.55	1.383	0.393
Crown Length	-0.123	0.281	-0.683	0.438	0.663
Root Length	0.015	0.454	-0.891	0.921	0.974
Mesio-distal width (MD)	0.463	0.175	-0.891	0.812	0.01*
Bucco-lingual width (BL)	2.144	0.23	1.685	2.604	<0.001*
Mesio-distal width at cervix (MDCV)	0.263	0.194	-0.125	0.651	0.18
Bucco-lingual width at cervix (BLCV)	1.399	0.226	0.948	1.851	<0.001*

SE = standard error; LCL = lower confidence limit; UCL = upper confidence limit

Table 4: Two Sample T-test results for premolar measurements

Parameter	Mean Difference	SE	95% LCL	95% UCL	p_value
Tooth Length	0.3	0.556	-0.815	1.415	0.592
Crown Length	0.023	0.82	-1.64	1.686	0.978
Root Length	0.738	0.561	-0.392	1.868	0.195
Mesio-distal width (MD)	0.477	0.494	-0.392	1.481	0.341
Bucco-lingual width (BL)	1.907	0.24	1.425	2.39	<0.001*
Mesio-distal width at cervix (MDCV)	0.983	0.295	0.391	1.575	0.002*
Bucco-lingual width at cervix (BLCV)	0.829	0.441	-0.059	1.718	0.067

SE = standard error; LCL = lower confidence limit; UCL = upper confidence limit

Discussion

3D scanning technology has evolved in recent years and has helped researchers to scan and archive skeletal and dental specimens from archaeological sites and museum collections around the world.[15] 3D surface scanners change the capacity to specifically measure the body type, form and surface area of the object[16]Researchers are also utilizing 3D surface imaging methods to examine taphonomic changes in cadavers.[17]It has also been noticed that the crime scenes captured using these methods gave better results when compared with 2D photography.[18,19]In order to use such systems, the precision and reliability of the same must be assured.[20-22] Three-dimensional scanning technology can effectively be used for preservation of evidence as it reduces the chances of the evidence being destroyed or damaged.

To our knowledge, limited studies have been done in the areas of digital odontometrics to test the reproducibility and accuracy

of conventional and digital methods. In our study, for premolars, statistically significant difference between physical and digital metrics was observed between mesio-distal width (MD), bucco-lingual width (BL) and bucco-lingual width at cervix (BLCV) whereas no significant difference was observed between conventional and digital measurements for tooth length, crown length, root length and mesio-distal width at cervix (MDCV). For molars, variation was observed between physical and digital metricsof mesio-distal width at cervix (MDCV) and bucco-lingual width (BL) whereas statistical agreement was observed between conventional and digital measurements for tooth length, crown length, root length and mesio-distal width (MD) and bucco-lingual width at cervix (BLCV).The inconsistencies that were observed in the measurements could be attributed to a number of factors like digital data procured was transferred into the Geomagic studio 13 software that was visualised without color and texture information opposing to the physical model leading to over and/or under estimation of measurements. This would be especially true for MDCV (in molars) and BLCV (in premolars) where at cervix textural differences can be observed from the surrounding teeth structure which cannot be appreciated in the plain digital model due to little or no texture. Secondly, the location of the landmarks digitally can be an issue and the examiners opinion concerning the exact location of a point can randomly vary, these errors can be rectified if the examiners are trained previously to navigate the 3D models and points are defined precisely. These observations are consistent with the observations discussed by Lee et al[7] related to discrepancies seen in digital measurements. Occasionally excessive data processing may lead to the discrepancy.[23] Park et al[22] performed a test to assess the efficiency of 3D laser scanning by testing 33 parameters on 30 skulls both digitally and conventionally where a significant disparity between the 3 variables out of the selected 33 parameters was reported They concluded that 3D laser scanning is a valuable and effective form for craniometric analysis.

Amuk et al[24] recorded identical results to our analysis while comparing tooth size (mesiodistal width of each tooth) measurements of conventional and scanned plaster models. The mean values for premolar and molar measurements were 6.9 ± 0.4 mm and 10.9 ± 0.9 mm respectively, close to the mean values of premolar and molar mesiodistal width (MD) measurements of our study. The findings from the studies by Kanno et al [25] Redlich et al [26] and Santoro et al [27] also showed results in concordance to the present study. Zilberman et al[28] tested the feasibility of tooth size measurements using traditional and 3D digital orthodontic models, where he carried out measurements using artificial teeth. Measurements conducted both digitally and manually on independent premolar (median= 6.7 mm) and molar (median= 10.8mm) showed similarities to our study to our study.

Human imprecision is an inherent cause of error in comparative studies. While placing the tip of digital calliper, ambiguity in dental landmarks (fixed or predefined) could create difficulties in taking those proportions, leading to differences in measurements.[24,29] In addition, as reported by Tocheri,[30] the quality of the file recorded by the laser scanner is defined by the 3D software, algorithms, and the skill of the individual operating the scanner. The 3D scanning technology is a newly developed technology and there are currently no specific guidelines developed for scanning, post-processing and metric analysis 3D digital models. Emphasis should be given to fix the modelling parameters to avoid discrepancies. It should also be noted that models with texture information be used to analyse the landmarks efficiently. More of these experiments are required to analyse the findings so that there is a transparency in understanding about the accuracy and consistency of the measurements.

Conclusion

Digital technologies provide advantages over traditional methods, such as maintaining original data with limited human interference, effective preservation, simple data sharing, reproducibility of knowledge, and ensuring the protection of not degenerating over time. Under the scope of this study, digital methods are a viable alternative to traditional dental measuring methods, although certain structured procedures and standards should be developed to capture the data in order to address the limits of the usage of digital systems. Future research with a wider sample size and predefined landmarks is indicated to determine the metric and non-metric characteristics.

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ORIGINAL ARTICLE

Finger-ball dermatoglyphics and its indices among Bhil population of Udaipur, Rajasthan

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Abstract
Many years ago, the research on epidermal ridges was published by Cummins and Midlo (1943). Cummins and Midlo also coined the term dermatoglyphics (derma- skin, glyphe- carvings) for the scientific study of ridges. The purpose of the present study is to know various finger- ball patterns of 200 Bhil individuals (male-100 & female- 100) of tehsil Burgeon, Udaipur, Rajasthan and to compare the variations or differences among these two gender groups. The analyses were done in accordance with the method proposed by Cummins and Midlo (1943). The pattern types, total finger ridge count (TFRC) and Absolute Finger ridge count (AFRC) were calculated and analyzed among the entire sample of Bhils. Loop showed the highest frequency in both the sexes (males – 56.9%, females – 63.6%) and whorls found with the frequency of males 35.8% and females – 28.8%. arches were found 7.6% in males and 7.3% in females.

Keywords
Bhil population; Dermatoglyphics; Finger-ball pattern; Udaipur

Introduction

The epidermal ridges on fingers, palms, soles and toes of humans are not smooth. It is grooved by curious ridges, which form a variety of configurations. The high variability of these configurations makes them useful in personal identification, studies of inheritance, racial variation, and other biological aspects of dermatoglyphics. Dermatoglyphics (derma = skin; glyphic = carvings) is the scientific study of epidermal ridges. The term dermatoglyphics was proposed by Cummins and Midlo in 1926 and published a monograph on the scientific study of epidermal ridge configurations in 1943.[1] Early research in dermatoglyphic studies reported that the work of Grew described the sweat pores with epidermal ridges and their arrangements.[2] Bidloo's work on human anatomy includes the description of the detailed arrangements of the ridges on digits.[3] After that Malpighi briefly explained the ridge configurations and pattern designs microscopically.[4] These are the earliest scientific descriptions of dermatoglyphics. The significance of dermatoglyphics has been increased in personal identifications. The work of Faulds based on his observations points out that chance prints left at the crime scene would be important evidence for criminal identification.[5] Galton classified the first scientific method of fingerprint patterns into whorls-loop-arch (W-L-A). Galton also pointed out ridge characteristics and described a method for taking prints.[6]

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Most of the investigators have proposed principles and definitions for the analysis of dermatoglyphics. The earlier proposed study has been reviewed by Cummins and Midlo (1961).[1] This study reported the relationship between unusual dermatoglyphic features and chromosomal abnormalities, so the use of dermatoglyphics in medical and genetics has increased rapidly.[7] Dermatoglyphics was often claimed to be associated with several genetic diseases like Down's syndrome,[8] Turner's syndrome,[9] Klinefelter's syndrome,[10] Alzheimer,[11] Schizophrenic disease,[12] Epilepsy,[13] Congenital heart disease,[14] Diabetes mellitus,[15] Leprosy,[16] Hypertension,[17] Bronchial asthma,[18] Pulmonary tuberculosis,[19] Breast Cancer[20] and Sickle cell anemia.[21]

Dermatoglyphics also plays a very important role in Anthropological research that dermatoglyphic configurations are very highly variable not only for individual studies but also for population studies. Previous studies suggest that the works and literature on dermatoglyphics of tribal and other populations and their findings were reviewed from the work of Sen and Kanchan (2011),[22] Namouchi (2011),[23] Mbaka et al. (2016),[24] Gupta and Singh (2018),[25] and Adetona and Shokunbi (2019).[26]

Anthropologically, India is a developing country with a richness of diversity and vitality of different cultures. The most beautiful feature of Indian societies is the diversified culture of Tribal and Caste populations. They largely inhabit the hilly and plain regions of the country. One of the largest tribes of Indian culture is Bhil, the ancient non-Aryan inhabitants of Aravallis, populated in four states of our country Rajasthan, Gujarat, Maharashtra, and Madhya Pradesh, have been studied in different perspectives at a different time.[27] The Bhils are having generally medium stature, dark skin, and thick hair. The Bhils are a very hard working and brave people in the field of Agriculture and cultivation and they live a simple lifestyle.

Thousands of years ago, their ancestors would have led similar lives, using their knowledge of farming land and domesticating animals in much the same ways as they do today.

In the present paper, the various characteristics of Finger ball dermatoglyphics of the Bhil population of Rajasthan are quantitatively described. The study aims to understand and analyzed the bilateral finger ball patterns of Bhils to determine the variation and bisexual differences between the Male and Female of Bhils of Udaipur, Rajasthan.

Materials and Methods

The present study is based on bilateral finger-ball prints of the Bhil population of tehsil Burgeon, Udaipur, Rajasthan. The data were collected from two schools Rajkiya Uchh Prathmic Vidhayalaya, Dhinkli, Senior Secondary School, Main Dhinkli and different parts of the tehsil Kanela Gaon, and Wada Gaon. The finger-ball prints of 200 individuals (100 males and 100 females) were collected by using random sampling method. Although, the fingerprints do not change with age, the fingerprints of participants aged 10 years above were taken into consideration in order to get a clear fingerprint for better evaluation.

The analysis of data was performed by following the methods used by the Cummins and Midlo (1943). The finger-ball prints were taken following ink-pad method, using Gesterner's ink, fingerprint paper, glass slab, cotton pad, duster, towel, soap, magnifying glass and folding lens. Statistical analysis was done through SPSS for evaluating the frequency, mean, standard error and standard deviation. Student's *t*-test and Chi-square test were used for calculating the difference between the means of the male and female groups. Three types of pattern indices were calculated in this study which is mentioned below.

Dankmiejer's Index= Arches×100/Whorls

Furuhata's Index= Whorls ×100/Loops

Pattern Intensity Index=2 × Whorls+ Loops/number of fingers

Results

The data analyses revealed that in males, loop showed the highest frequency (56.9%), whorl showed the medium frequency (35.8%) and arch was 7.3% in both hands. In females loop showed the highest frequency (63.6%), whorl was 28.8% and arch was 7.6%. In both groups loop showed the highest frequency in females (63.6%) than males (56.9%) and whorl frequency was greater in males (35.8%) than females (28.8%). Arches were higher in females (7.6%) than males (7.3%). Overall distribution showed loops were found in highest frequency (60.25%) than whorls (32.3%) and arches (7.45%) (Table 1). Table 2 showed all parameters (W-L-A) were found to have significant differences among Bhil males and females (both hands) while the difference between male right hand vs. male left hand was found to be non-significant (*p*-value-0.12).

The various pattern indices (Table 3) among male and female of Bhils population of Udaipur, Rajasthan showed the value of Dankmeijer's index for Bhil males was 20.39 and females were 26.38. The value of Furuhata's index for Bhil males was 60.91 and females were 45.28. The value of pattern intensity index for Bhil males was 12.85 and females were 12.12. Overall pattern type indices for Bhil population were showed the value of Dankmeijer's index was 23.06 and the value of Furuhata's index for Bhil population was 53.60. The value of pattern intensity index for Bhil population was 12.48. The *t*-tests were calculated to know variation among the males and females (both hands) based on Total Finger Ridge Count (TFRC) and Absolute Finger Ridge Count (AFRC). On applying the *t*-test, it was observed that the variation between Bhil males and females was statistically significant. (Tables-4 and 5)

Table 1: Digit-wise distribution of finger-ball pattern types among the Bhil males and females

Pattern type	Males (n=100)						Females (n=100)						Total (n=200)	
	Right hand		Left hand		Both		Right hand		Left hand		Both		M +F	
	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%
Whorl	183	36.6	175	35.0	358	35.8	135	27.0	153	30.6	288	28.8	646	32.3
Loop	273	54.6	296	59.2	569	56.9	339	67.8	297	59.4	636	63.6	1205	60.25
Arch	44	8.8	29	5.8	73	7.3	26	5.2	50	10.0	76	7.6	149	7.45
Total	500	100	500	100	1000	100	500	100	500	100	1000	100	2000	100

Table 2: Differences between male and female hands

Variables	Value of Chi Square	*p*-value
Male right hand vs. Male left hand	4.1907	0.12
Female right hand vs. Female left hand	11.4775	0.00
Male right hand vs. Female right hand	18.9915	0.00
Male left hand vs. Females left hand	7.0596	0.02
Males vs. Females (both hands)	11.3709	0.00

Table 3: Pattern type indices of Bhil males and females

Pattern type Indices	Values		Total
	Males (n=100)	Females (n=100)	M+F (n=200)
Dankmeijer's Index=Arches x 100/Whorls	20.39	26.38	23.06
Furuhata's Index=Whorls x 100/loops	62.91	45.28	53.60
Pattern Intensity Index=2 x Whorls + Loops/n	12.85	12.12	12.48

Table 4: *t*-test variation among Bhil males (n=100) and females (n=100) based on Total Finger Ridge Count (TFRC)

Population	Mean $\bar{X}$	Standard Deviation S.D.	Standard Error of Mean	Value of *t*-test	P-value
Males	142.61	44.92438	4.492438	3.1005	P<0.002
Females	123.47	42.34024	4.234024		

Table 5: Showing *t*-test for variation among Bhil males (n=100) and females (n=100) based on Absolute Finger Ridge Count (AFRC)

Population	Mean $\bar{X}$	Standard Deviation S.D.	Standard Error of Mean	Value of *t*-test	P-value
Males	194.97	90.16802	9.016802	3.4649	P<0.000
Females	154.266	75.29941	7.529941		

Table 6: Showing the different finger ball pattern frequencies among gender of different populations

Population	n	Frequencies (%)						Studies
		Whorl		Loop		Arch		
		N	%	N	%	N	%	
Japanese (M)	268	1072	40.0	1517	56.6	91	3.4	Maoka, 1938
Japanese (F)	233	970	41.6	1274	54.7	86	3.7	
Koreans (M)	2677	12876	48.1	13332	49.8	562	2.1	Tanaka,1937
Koreans (F)	517	2409	46.6	2549	49.3	212	4.1	
Chinese (M)	211	1108	52.5	961	45.5	41	1.9	Shino & Mikami, 1922
Chinese (F)	97	428	44.2	518	53.4	24	2.5	
Javanese (M)	1000	3590	35.9	6130	61.3	270	2.7	Dankmeijer's, 1938
Javanese (F)	1000	3270	32.7	6400	64.0	330	3.3	
Bhutanese (M)	69	370	53.6	315	45.6	5	0.7	Bhasin, 1966
Bhutanese (F)	16	76	47.4	82	51.3	2	1.3	
Tibetans (M)	156	940	60.25	608	38.99	12	0.76	S. C. Tiwari, 1967
Tibetans (F)	150	730	48.67	737	49.13	33	2.20	
Muslims of Maharashtra (M)	240	676	28.17	1256	52.33	84	3.50	Kapoor & Badiye, 2014
Muslims of Maharashtra (F)	240	668	27.83	1156	48.17	128	5.33	
Jaunsaris (M)	70	300	42.8	380	54.3	20	2.90	Pathan & Mondal, 2020
Jaunsaris (F)	100	389	38.9	552	55.2	59	5.9	
Bengali Hindus (M)	66	263	39.85	287	43.48	58	8.79	Maity & Dolai, 2021

Table 6 showed the sex-wise distribution of finger ball pattern frequencies among various populations of world in which Tibetan males showed highest frequency of whorls that was (35.9%) and the lowest frequency of whorls among Javanese males (35.9%) whereas in Tibetans females had higher frequency was (48.67%) and lowest frequency among Javanese females (32.7%). In the present study the frequency of whorls among Bhil males (35.8%) falls between these two ranges that is Javanese male (35.9%) and Tibetan males (60.25%) respectively. Whereas the present study showed the frequency of whorls among females was (28.8%) which was slightly lower than Javanese females (32.7%) [28,29]. The lowest frequency of whorls was found to be in muslim females with 27.83%.[38]

The prevalence of Loops showed the highest frequency among Javanese males (61.3%) and lowest among Tibetans males (38.99%) whereas Javanese females showed highest frequency of loops that was (64.0%) and lowest in Korean females (49.3%). The present study showed the frequency of Loops in males was (56.9%) females were showed 63.6%. Here, the frequency of females was higher in present study as compare to other population except Javanese females. In present study in males loop showed very similar frequencies with Japanese males.[28, 29] Arch patterns showed highest frequency in Bengali hindu females (12.26%)[31] and Jaunsari females (5.9%)[30]whereas lowest among Bhutanese males (0.7%) [32]And Tibetan males (0.76%). In present study (Bhils) arches were found in highest frequency among Bhil males (7.3%) and females (7.6%) as compare to other population in Table 6.

Discussion

There are various finger-ball Dermatoglyphic studies that were performed on the tribal and caste population such as the one that was conducted on the Naikas of Gujarat. In 1988, Mukherjee Studied the Naikas of Gujarat and found the percentage distribution of whorls (45.35%) loops (52.00%) and arches (2.65%) respectively. This study also indicated that the Naikas were close to Gujarati Vaisyas and Bhils of Rajasthan, Charans of Gujarat.[32] Vadde et al., (2020) conducted a research on 186 medical students of Andhra Medical College, Visakhapatnam, India and analyzed the Loops had the highest frequency (55.65%) followed by whorls (33.33%), arches (8.01%) and composites showed the least number with (3.01%).[33] In 1982, S. R. Walimbe studied the Korku population of Amraoti District of Maharashtra. In his study 100 individuals were investigated and found the frequency of whorls (52.40%) was the highest while the frequency of the loops (44.80%) being the next highest to that of the whorls. Arches occurred in very few frequency 2.80% respectively.[34] Ching Cho (1998) conducted a research on 193 individuals of New Zealand Samoans and found higher frequency of whorls (males-55.6% and females- 65.6%) than loops (males- 43.6% and females-33.7%) and arches (males- 0.8% and females- 0.7%).[35]

Finger-ball dermatoglyphics of the Bagathas, a dominant endogamous tribal population of Araku Valley in Andhra Pradesh, India were analyzed by G. G. Reddy in 1975. In this study Reddy investigated the finger prints of 235 males and 235 females and it was found that loops were higher in females (57.58%) than in males (49.19%). This study also showed the Sex differences in the distribution of the patterns were

statistically significant.[36] In 2015, Kapoor and Badiye studied 480 healthy Muslim individuals (240 males and 240 females) from Maharashtra, India. It was observed that in both hands of males and females whorl found in medium frequency (males- 28.17% and females- 27.83%) and loops were higher (males- 52.33% and females- 48.17%) than arches (males- 3.50% and females- 5.33%) respectively.[37] Luke Chukwumah Anyanwu (2020) investigated the variations in finger dermatoglyphics among Esan speaking tribe of Edo State, Nigeria. Total 500 indigenous were sampled from 3 randomly selected Local Government Areas. The results of his study indicated the prevalent of fingerprint pattern of the Esan speaking tribe of Edo State to be loop (54.44%), followed by the whorl (30.96%) and then arches (14.60%).[38]

The present study has revealed that in both males and females of Bhil population of Udaipur, Rajasthan loop showed the highest frequency (60.25%) followed by whorl (32.3%) and arch (7.45%). While observing the population variation of Bhils it was found to be significant on the basis of Total finger ridge count (TFRC) and Absolute finger ridge count (AFRC).

Conclusion

Finger ball dermatoglyphics of 200 Bhils had been analyzed, the following frequencies of the pattern types were observed- whorls (32.3%); Loops (60.25%); Arches (7.45%). The purpose of the present study was to know variations in the finger ball patterns among the males and females of Bhil population of Udaipur, Rajasthan. In both groups, loops were found to be in higher frequencies than whorls. Population variation among Bhils found to be significant on the basis of TFRC and AFRC. The various Pattern type indices among Bhils showed the Dankmeijer's index was 23.06 and Furuhata's index was 53.60 the Pattern intensity index was 12.48 respectively.

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ORIGINAL ARTICLE

Fingerprint analysis and gender predilection among medical students

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Abstract

Fingerprint is an impression of friction skin ridges, known as dermal ridges or dermal papillae, on a surface and its study is known as Dermatoglyphics. The word "Dermatoglyphics" indicates the study of epidermal ridge pattern on fingers, palm, and soles. Dermatoglyphics are constant and individualistic and form the most reliable criteria of identification.In the present study an attempt has been made to study the fingerprint patterns in medical students at M.G.M. Medical College Indore. Fingerprint patterns were studied in 194 students, 107 males and 87 females. Dermatoglyphic prints of the fingertips were taken using the ink method. The main objective of the present study is to evaluate the distribution of dermatoglyphics fingertip patterns in both hands among males and females and the findings of the study are compared with the available data.

Keywords

Dermatoglyphics; Fingertip patterns; Identification; Gender differences

Introduction

Personal identification through fingerprints has been known since long and is considered as the greatest contribution to the law enforcement. Fingerprint is considered one of the best, cost-effective, constant, individualistic and legitimate proofs for identification of an individual.[1]

Harold Cummins considered as the father of dermatoglyphics first coined the term in 1926.[2]The word "Dermatoglyphics" indicates the study of epidermal ridge pattern on fingers, palm, and soles. The dermatoglyphic pattern makes their appearance as early as 10 weeks of intrauterine life.[3]Development of ridges was found to be affected by genetic and environmental factors. Once formed these pattern do not change throughout one's life,[4]until destroyed by decomposition of the skin after death.[5]However, they may be altered or scarred in conditions like leprosy, electrical injury, exposure to radiation, ridge alteration in eczema, scleroderma, ridge distance change in rickets etc. Various physical evidences used for identification are finger prints, DNA profiling, lip marks, foot prints, bite marks etc. Study of fingerprint patterns is considered to .be the most reliable and absolute method of identification. Finger prints follow the Locard's Principle of Exchange. The secretions in the fingerprints contain residues of various chemicals and their metabolites which can be detected and used for the forensic purposes.[6]Galton classified different fingerprint patterns on the basis of their primary pattern as loops, whorls and arches.[7]Loops are the patterns that start from one side, move towards the centre, curve backwards and terminate on the same side. Whorls are circular or spiral arrangement of ridges in the centre, and in Arches, the ridge lines start from one side and end at the opposite end Double loops and central pocket-loops are classified under whorls. The aim of the present study was to study the distribution of fingerprint patterns on different digits in males and females and to find if any variation occurs between both sexes for both hands.

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Material and Methods

The present descriptive study was carried out in the Department of Forensic Medicine & Toxicology, M.G.M. Medical College Indore (M.P.) during the year 2020-2021. The total sample comprised of 194 medical students (107 males and 87 females). Age group 19-28 years was targeted considering their accessibility to the department of Forensic Medicine. Prior approval has been taken from the institutional Ethics Committee. All the subjects were briefed about the purpose of the study and written informed consent was obtained from each of them before taking the samples. Only healthy medical students free from deformities of fingers or hand or disease or birth defects were included in the study. Foreign students and any medical student having deformity like permanent scars on their finger or thumb, or hand deformities following injuries or birth defects or any kind of disease, those with worn fingers, extra webbed or bandage fingers were not included as part of the study. Each subject was asked to wash their hands thoroughly with soap and water and dry them using a towel. Plain or method was used to take finger-prints of right and left hand. The subjects were then instructed to press the bulb of their fingers on the stamp pad of Camlin. The impression was obtained by gently pressing the inked surface of the tip of finger

on an unglazed plain paper which consisted of ten different blocks for ten fingers of right hand and left hand respectively. Each finger assigns number according to the order in which it is located in hand, beginning with the right thumb as number one and ending with the left little finger as number ten.

After obtaining the finger prints the basic details such as name, age and sex was also collected. Primary patterns loops, whorl and arches based on the appearance of ridge lines were observed with the help of a powerful hand magnifying lens. Precaution was taken to avoid sliding of fingers to prevent smudging of the print.

Results

Fingerprint pattern analysis of 1940 fingers (194 subject X 10 fingers of right and left hand) showed that, overall loop pattern 1098(56.6%) were the most commonest type of finger print pattern in both hands among males and females followed by whorls 684(35.2%) and arches 158(8.3%) pattern as shown in Table 1.

Table 1: Distribution of Primary Fingerprint Patterns in Right and Left Hands

Digits		Gender		Pattern of Fingerprint			
		Male	Female	*n*	Loops (%)	Whorls (%)	Arches (%)
Thumb	Right	107	87	194	105(54.1)	83(42.8)	6(3.1)
	Left	107	87	194	118(60.8)	65(33.5)	11(5.7)
	R+L	214	174	388	223(57.5)	148(38.1)	17(4.4)
Index Finger	Right	107	87	194	89(45.9)	68(35.0)	37(19.1)
	Left	107	87	194	87(44.9)	68(35.0)	39(20.1)
	R+L	214	174	388	176(45.4)	136(35.0)	76(19.6)
Middle Finger	Right	107	87	194	127(65.5)	46(23.7)	21(10.8)
	Left	107	87	194	123(63.4)	48(24.7)	23(11.9)
	R+L	214	174	388	250(64.5)	94(24.2)	44(11.3)
Ring Finger	Right	107	87	194	84(43.3)	103(53.1)	7(3.6)
	Left	107	87	194	84(43.3)	104(53.6)	6(3.1)
	R+L	214	174	388	168(43.3)	207(53.4)	13(3.3)
Little Finger	Right	107	87	194	138(71.1)	51(26.3)	5(2.6)
	Left	107	87	194	143(73.7)	48(24.7)	3(1.6)
	R+L	214	174	388	281(72.4)	99(25.5)	8(2.1)
All Digits	Right	535	435	970	543(56.0)	351(36.2)	76(8.9)
	Left	535	435	970	555(57.2)	333(34.3)	82(8.5)
	R+L	1070	870	1940	1098(56.6)	684(35.2)	158(8.3)

Table 2: Distribution of number of pattern of finger prints among males and females

Type	Male	%	Female	%	Total	Percentage
Loops	638	59.6	460	52.9	1098	56.6
Whorls	347	32.4	337	38.7	684	35.2
Arches	85	8.0	73	8.4	158	8.2
Total	1070	100	870	100	1940	100

While loops were the predominant patterns on the thumb, middle and little fingers, predominance of whorls was evident on thumb, index and ring fingers. Loops were mostly noticed on little finger 281(72.4%) followed by middle finger 250(64.5%) and thumb 223(57.5 %).

Frequency of whorls was maximum on the ring finger 207(53.4%) followed by thumb 148(38.1%) and index finger 136(35.0%).

Frequency of arches was predominant in index finger 76(19.6%) and middle fingers 44(11.3). There was insignificant difference in overall distribution of fingerprint pattern in corresponding fingers of both hands among both males and females.

Table 2 shows the distribution of number of pattern of fingerprints among both the male and female. The frequency of distribution of loop pattern was found to be higher in males (59.6%) as compared to females (52.9%) whereas the whorl pattern was more predominant in females (38.7%) as compared to males (32.4%). Similarly, frequency of distribution of arch pattern was more in females (8.4%) than males (8.0).

Discussion

The present study was carried out in the Department of Forensic Medicine & Toxicology, M.G.M. Medical College, Indore (M.P.) and it has been compared with other similar studies carried out in different parts of the world to bring out the similarities and differences.

The finger ridge pattern is genetically determined and highly unique. Worldwide percentage distribution of loops, whorls, arches and composite is approximately 65%, 25%, 7% and 2-3% respectively.[8] Our study of fingerprint patterns on individual digits revealed preponderance of loops on little and middle finger, whorls on ring finger and thumb and arches on the index finger in both hands, which is in accordance with the study done on British subjects[9] and to the results of kanchan et al[10] and amit et al[11] on Indian population. However, in our study distribution of arches on the index finger was similar, that of whorls higher and loops on lower side when compared to British population.[9] Frequency of loops and whorls in our study was higher and that of arches lower when compared to study conducted by Bharadwaja et al[6] in Ajmer.In our study arches though less in frequency were observed more in female medical students. In study conducted by Rao et al[12] in Nellimarlano arches were reported in any of the fingers of the medical students.

It has been observed that particular type of patterns is relatively more common in one of the genders despite loop being commonest pattern. The loop pattern were common in male while whorl and arch patterns were found to be predominant

among female students. This is in accordance to a studyconducted by shrestha et al[13]in Nepalese population.

Conclusion

In this study, ridge pattern analysis of fingers of right and left hand of all the subject are studied, compared and concluded that, over all loop pattern were the most commonest type of finger print pattern in both the sexes followed by whorls and arches pattern. There was a significant increase in frequency of loops in 5th digit and 3rd. there was predominance of whorls in 4th digit followed by 1st digit. Frequency of arches was predominant in 2nd digit and 3rd digit. The frequency of distribution of loop pattern was found to be higher in males as compared to females, while the whorl & arch pattern was more predominant in females.Distribution of fingerprint patterns was similar on both hands for both sexes.

Hence, it can be summarized that overall distribution of fingerprint patterns showed no bilateral significant difference between hands due to distribution of dermatoglyphic patterns being almost similar on both hands but showed an association between distribution of fingerprint patterns and gender. Frequency distribution of fingerprint patterns among subjects of this study i.e. Medical students differs from other population groups where Frequency of whorls is comparatively higher than that of loops. Therefore, similar studies in other population groups are desirable.

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A two-year retrospective survey of drowning deaths in the state of Goa

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Abstract
A two year retrospective survey was conducted spanning from 2017-2018 in the Department of Forensic Medicine and Toxicology on cases brought for postmortem as deaths due to drowning. A total of 220 cases of drowning in the state of Goa have been categorically analyzed and presented based on age, sex, fresh water or salt water drowning and the manner of death.The most common source of fresh water drowning was found to be rivers (40%). The study showed that accidental drowning (73.08%) was more common than suicidal (26.37%) and homicidal (1%) drowning. Highest number of deaths was recorded in the age group of 31-45 years, with higher male preponderance.

Keywords
Drowning; Fresh water; Salt water

Introduction

World Health Organization (WHO) had adopted the new definition at the first world congress on drowning in 2002 as "Drowning is the process of experiencing respiratory impairment from submersion or immersion in liquid." Outcomes are classified as death, morbidity and no morbidity.[1]The National Crime Records Bureau (NCRB) 2019 statistics show that in Indiaaccidental drowning contributed to 7.8% of accidental deaths in the country. Death by suicidal drowningwas adopted by 4.9% of the victims in 2018 and 5.2% in 2019. Rate of drowning deaths are at least three times higher in developing countries than in developed countries. Despite the significant numbers of deaths due to drowning, it continues to remain an invisible public health issue in most developing countries.[2]

Bodies recovered from water do not necessarily mean death to have occurred from drowning. External examination and autopsy findings are often non-specific, and the available laboratory tests are often inconclusive or controversial, due to which forensic diagnosis of drowning is considered one of the most difficult.[3] Goa being a coastal state has a significant number of deaths due to drowning every year. There is no record of any research done in this context which prompted the present study to be undertaken. The following survey was conducted to study the epidemiology of drowning in Goa.

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Materials and Methods

The current study is retrospective in nature and done by accessing autopsy reports and police inquest for cases of drowning over a period of two years (2017-2018) of Goa Medical College. Details such as age, sex, location of the body, manner of drowning were obtained from police inquest and autopsy reports, entered in a tabular form and analyzed to obtain the results. Ages of unknown bodies were taken as mean of assumed age. Bodies found in advanced stage of decomposition and cases with ambiguity with regards to diagnosis of drowning were excluded.

Results

A total of 221 cases were brought with alleged history of drowning over a span of two years (2017-2018). Out of these, 39 cases were excluded as per the exclusion criteriaand hence the sample size was 182 cases. Of the 182 cases, 155 cases comprised of males and 27 females. Males showed a higher preponderance of death due to drowning with a ratio of 6:1 when compared to females. Maximum mortality due to drowning was observed in the age group of 31-45 years. Table 1shows the age distribution of drowning cases.It was observed that 21% of deaths were due to drowning in salt water and 79% of cases was fresh water drowning. The most common source of fresh water drowning was found to be rivers (40%). Other sources in the descending order of frequency of drowning were in salt water (21%), lakes (14%), wells (13%), swimming pools (4%) and canals (3%). A very less proportion of drowning cases have been recorded from quarries, bath tubs and bucket of water constituting a total of 5%.The results are depicted in Table 2. The study showed that accidental drowning (73.08%) is more common than suicidal (26.37%) and homicidal (1%) drowning (Table 3).

Table 1: Number of cases in different age groups

Age Distribution	N
0-15 years	16
16-30 years	49
31-45 years	59
46-60 years	37
61-75 years	18
76-90 years	3
Total	182

Table 2: Source of recovery of body

Water Source	n
Rivers	72
Salt	37
Lakes	25
Wells	24
Swimming pools	8
Canals	6
Others	10
Total	182

Table 3: Distribution of manner of death in drowning cases

Manner of death	N
Accidental	133
Suicide	48
Homicide	01
Total	182

Discussion

Drowning is the 3rd leading cause of death due to unintentional injury.[4] The present study showed higher number of deaths due to fresh water drowning which is consistent with results derived from previous studies.[5,6]A study done in coastal city of Vishakhapatnam showed that majority of drowning cases were reported from saltwater.[7]Contrary to popular belief, drowning occurs more in fresh water than in salt water in Goa.In a study conducted by Kumar et al,most common fresh water source of drowning was water canal (55.37%).[8]This could be attributed to the fact that the study was conducted in a landlocked North Indian area.

An international study conducted in three countries by Peden et al highlights the importance of location and activity prior to drowning. Beaches and ocean/harbor locations were common in Australia and New Zealand, while lakes/ponds and bathtubs were common drowning locations in Canada. Boating prior to drowning was common in Canada.[9]

Common age group involved was varied in different studies. A study by Nayak & Karlawad observed 11-20years as the most common age group.[10] The most common manner of death wasaccidental. This was a common finding in almost all other similar studies. In India, drowning is one of the most opted mode of suicide by women.[11] Male dominance in drowning deaths were shown in many other studiesby Kanchan et al, Chowdhuryet al, Byard et al.[12-14]A study done by Kumar et al on pattern of drowning in rural area found that suicidal drowning is more common in males and accidental drowning is more in females and children.[15]Contrary to the findings in the present study, the study by Prasad et al revealed that women chose drowning as a mode of suicide significantly higher than men. A study conducted in Shanghai on people with psychiatric disorders on suicidal drownings, showed that suicides in males was common with a peak in 20-29 year old age group and males were observed to have died by suicidal drowning in warm and hot season.[17]In the present study, psychiatric evaluation of the deceased was not given consideration in analyzing the data, also, the source of the water in relation to the distance and accessibility by the person were also not considered.

While a number of case series and case reports of adult, child, and infant homicidal drowning exist, studies examining characteristics of large numbers of homicidal drowning (specifically homicide by drowning) are sparse. Its occurrence has, nevertheless, been noted to be far less common overall as compared to drowning by other manners of death, or even other types of homicidal asphyxial deaths such as strangulation.Homicidal drowning is mostly seen as having a low incidence due to many factors like lack of autopsy findings, insufficient investigative findings or statistical under reporting.[18] For e.g., only 12 cases out of 2617 homicides, were found to be homicidal drowning in a study by Modell et al.[19] Drowning is one of the leading causes of unintentional accidental deaths worldwide. Despite the finding of the present study that accidental drowning is the most common, it has not been scrutinized on the type of accidental drowning, which is a limitation in the present study. The study by Clemens et al specifically points out that recreational drowning was seen as the most common type of accidental drowning in younger population, followed by alcohol consumption, which were seen most commonly in the 20-34 year olds. Also, the study shows that lack of accompaniment was also an added risk to the number of accidental drowning.20

Drowning is one of the leading causes of unintentional injury in

childhood.21 A survey conducted by Dandona et al, on 224077 children aged 1-14 years in the state of Bihar, drowning deaths accounted for 7.2 %, 12.5% and 5.8% of all deaths in 1-4, 5-9 and 10-14 years age groups, respectively.22WHO on Global Report of Drowning mentioned that omnipresence of water sources and consequent daily risk of drowning had been highlighted as the single most important determinant of the large difference in drowning rates between the developing and developed countries.2 A study by Quan et al on characteristics of drowning by different age groups showed that "The highest rates were among those 0–4 years (31 per million), closely followed by those 15–19 years (30 per million). Lowest rates were among those 5–14 years (12 per million)"23.This study has pointed out the cases in relation to only accidental drowning. The results of the present study varies significantly with this finding, mostly because the current study focuses on a mix of all manner of death and hence the most common affected age group was determined as 31y – 45y. Such an increase in the pediatric population is most likely attributed towards the inattentiveness of the "look-out" or the guardian responsible.

Conclusion

Drowning is an underdiagnosed entity as a cause of death. Improved inquest panchnama furnishing accurate details about the case and scene of occurrence would strengthen the databases.The vast number of accidental fresh water drowning could have been avoided by employing adequate safety measures like putting signboards, teaching swimming, and not leaving children unsupervised. Data distinguishing death due to drowning in native population and tourists would reflect the true burden of the problem and help the authorities to adopt population specific preventive measures.

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ORIGINAL ARTICLE

Study of mortality trends & pattern in a tertiary care hospital in Kerala, South India

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Abstract

Mortality statistics are essential for the meaningful planning and allocation of resources for healthcare. It has been observed that in India, up-to- date, precise and reliable data regarding mortality patterns especially in the rural areas is inadequate or not properly documented. Data regarding mortality is often not analyzed and converted into a suitable information to be useful in knowing the common causes for death in specific and general populations. The mortality pattern at a Tertiary Care Hospital in Kerala from 2014-2018 and the sociodemographic characters associated with it were studied. The details from the case sheets were obtained and analyzed using descriptive methods. The total number of deaths recorded were 934, out of which, the maximum number of deaths has occurred in the elderly population (Above 60 Years). 11 cases are of infant deaths. The major cause for infant mortality was found to be preterm and extreme preterm birth. 576 deaths (61.6%) were males. Most number of deaths were due to Cardiovascular Causes (39.6%) followed by Malignancy (12.7%) and respiratory diseases (12.4%). Out of the 934 cases of deaths, 310 patients belonged to rural areas (33.1%). During the study it was noticed that the cause of death has been entered incompletely in many cases. Training of doctors & MRD faculty with respect to cause of death writing and ICD classification according to system wise has to be done periodically for better documentation which will help in future for data collection and easy analysis of the trends in disease and mortality.

Keywords

Mortality pattern; Epidemiology; Cause of Death; Hospital records

Introduction

India is undergoing a rapid epidemiological transition as a consequence of social and economic changes.[1] Yet, a wide disparity exists in the levels of mortality across its various regions and states. These differences reflect inequality in access to food, drinking water, medical care, sanitation and other basic human needs. These changes also arise from variations in risk factors, behavioral patterns and social context in various parts of the country.[2] Mortality may also arise during surgical care as a result of the pathological process necessitating the surgery or as a complication of the surgical procedure or anesthesia. Delay in seeking medical help for the ailment from the people, delay in diagnosis and treatment, medical errors and limited healthcare facilities also contribute significantly to mortality.[3]

Medically certified information is available for less than 30% of the estimated 50.5 million deaths that occur each year worldwide.[4] India has a huge geographical area in which the residing population is diverse in terms of lifestyle, social status and language. Hence up-to- date, precise and reliable data regarding mortality patterns especially in the rural areas is inadequate or not properly documented.[1] Over 75% of the annually estimated 9.5 million deaths in India occur at home and a large majority of these do not have a certified cause.[5]

Even though Data regarding mortality is recorded in the medical record departments in hospitals, it is often not analyzed and converted into suitable information that would be useful in knowing the common causes and reasons for death in specific and general populations. Up- to-date and precise data regarding causes of mortality is crucial for combating and preventing the occurrence of potentially life-threatening diseases and practices. Well documented Data also helps in assessing health status of the population in the particular area and the quality of healthcare available to them, such that better healthcare systems can be devised and implemented.

India urgently needs reliable quantification of causes of death. Mortality pattern being a key indicator of the consequent health effects, a great heterogeneity exists between different parts of India regarding which specific cause of death is the most prevalent in these regions.

Mortality statistics are essential for the meaningful planning of healthcare and allocation of resources for the same.[2]

This study was conducted with the aim of overcoming these

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drawbacks and further contributing to strengthen the healthcare system for planning necessary preventive measures to bring down the mortality rates. This study intended to find out the various causes of deaths that have occurred during a period of 5 at a tertiary care hospital, in Kerala, South India and analyzing the sociodemographic associations to these causes.

Materials and Methods

This Retrospective Hospital Record based study was conducted in PK Das Institute of Medical Sciences, Vaniamkulam, Ottapalam, Kerala, South India. Ethical clearance for this study was obtained by the Institutional Ethical Committee.The identities of the deceased persons whose data was obtained from the medical records has not been revealed in any of the documents related to the study.

Data regarding mortality from January 2014 to May 2018 were collected from Medical Records Department of the institute. The details from the case sheets were obtained regarding the IP Number, age, gender, address, occupation of deceased, time and month of death and cause of death. Deaths having associated medico legal components and the data regarding which were not complete were excluded.Data was collected using Hospital based death records and categorized according to ICD-10 Classification for classification of causes of Mortality. It was then entered using MS Excel and IBM-SPSS and was analyzed using descriptive methods like frequency, proportions, percentages and charts.

Results

This study regarding Mortality Pattern in a tertiary care hospital conducted as a part of ICMR STS Project 2019 reveals information about Mortality over 5 years (from January 2014-May 2018). According to the study, the Hospital has received a total of 79116, In -patients in the study period,out of which deaths occurred in 934 patients, constituting for 11.8% of the total admissions. The year wise distribution of In-patient admissions, deaths and mortality rate is shown in Table 1. The mortality rate among the Hospital In-Patients over 5 years was calculated as Deaths per 1000 admissions. The trend of the mortality rate is shown in Figure 1.

Out of the 934 Deaths recorded, the maximum number of deaths has occurred in the elderly population (Above 60 Years). The number of deaths among infants was 11, while that among children from 1-5 years was 5. The number of deaths in different age groups is shown in Table 2.

The records regarding the total In-patients in each age group was not available and hence age specific mortality rate could not be calculated.

Out of the 934 deaths recorded, 576 (61.6%) were males and 358 (38.3%) were females. The year wise gender based distribution of cases is depicted in Figure 2.

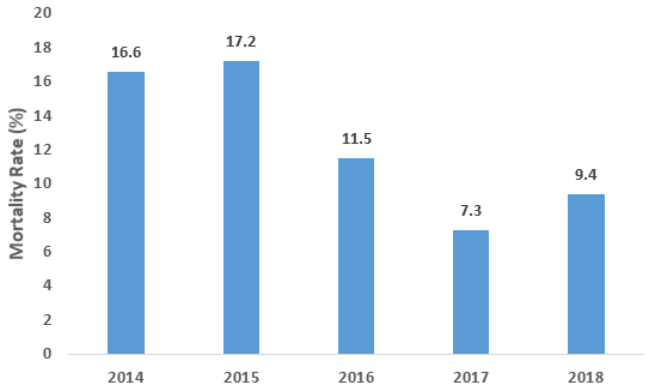

Figure 1: Trends of mortality from 2014 to 2018 per 1000 admissions

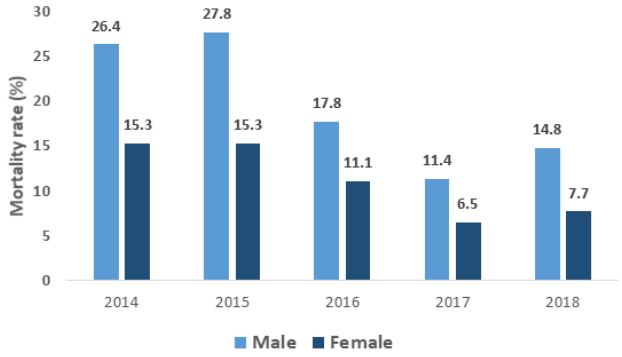

Figure 2: Distribution of Mortality rate According to Gender above 16 years of age

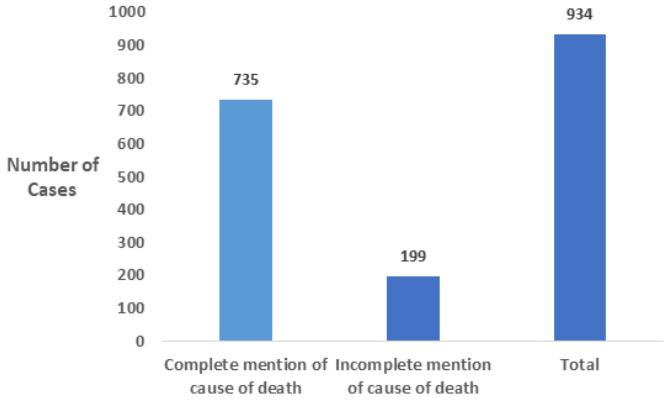

Figure 3: Cause of death as mentioned in the case

As the overall data in the medical records department in the institution is divided into males, females and children, we further excluded children from the male and female data. Hence out of the 934 deaths recorded in the study, 566 were male patients, 342 were female patients and 26 were separated as children. This data excluded children below 16 years of age.

The overall mortality rate for children (<16 years) was found to be 1.5 per 1000 in patients with mortality rate for each year as 2.8, 1.9, 1.1, 0.9 and 1.4 per 1000 inpatients in the years2014, 2015, 2016, 2017 and 2018(Jan-May) respectively.

Out of the 934 deaths recorded in the study, 11 cases are that of infant deaths. 5 of the 11 deaths have occurred within the first 24 hours of birth, 1 between 8-28 days and the rest 5 between 28 days to 1 year.

Out of the 11 cases of infant deaths, 3 were due to Preterm birth and 3 due to Extreme Preterm birth. Sepsis and Inborn Errors of metabolism are responsible for 2 deaths each. Congenital abnormality accounts for 1 death.

Out of the 934 deaths recorded in the study, the most number of patients belonged to Palakkad (784 cases) followed by Trissur(122 cases). 11 patients belonged to Malappuram. The rest of the cases are reported from other parts of Kerala like Ernakulum, Kozhikode and Kannoor (12), other parts of India (4) and 1 case is recorded from outside India.

Out of the total number of deaths, 310 patients Belonged to rural areas (33.1%), 320 to semi-rural areas(34.2%) and 304 to Urban areas(32.5%).

In the study, it has been observed that most of the deaths are due to Non-communicable causes (90.7%). Communicable causes only account for 9.3% of the deaths.

Out of the 934 Death Records analyzed in the study, it was observed that the most number of deaths were due to Cardiovascular Causes (370 out of 934- 39.6%). They constituted for 47.2%, 47.3%, 32.1%, 31.2% and 38.9% deaths in the years 2014, 2015, 2016, 2017 and 2018 respectively. Followed by Malignancy (12.7%) and respiratory diseases (12.4%). Gastrointestinal diseases accounted for 3.5% of the deaths while Metabolic and Neurological Disorders Caused 6.6% and 6.9% of the deaths respectively. 5.8% of the deaths were due to renal causes and Infectious diseases were responsible for 8.4% of the deaths. Premature Birth caused 0.6% of the Deaths. The Rest 3.1% of deaths were Caused by Other Diseases like anemia, Hypovolemic Shock (Table 3).

Table 1: Distribution of In-patient admissions and deaths

Year	In-Patient Admissions	Deaths	Mortality Rate (%)
2014	11086	180	16.6
2015	14289	247	17.2
2016	21539	249	11.5
2017	22188	163	7.3
2018 up to May	10014	95	9.4
Total	**79116**	**934**	**11.8**

Table 2: Distribution of deaths among different age groups

Age	2014	2015	2016	2017	2018 (Jan-May)	Total
< 1 Year	3	1	1	4	2	11(1.2%)
1-5 Years	1	3	1	0	0	5(0.5%)
5-14 Years	3	1	3	0	1	8(0.9%)
14-49 Years	17	26	24	11	6	84(9%)
49-60 Years	25	38	26	26	8	123(13.2%)
Above 60	131	178	194	122	78	703(75.3%)
Total	180	247	249	163	95	934(100%)

Table 3: Distribution of cause of death according to system involved

Causes	2014	2015	2016	2017	2018	Total
Cardiovascular Diseases	85 (47.2%)	117 (47.3%)	80 (32.1%)	51(31.2%)	37 (38.9%)	370 (39.6%)
Respiratory Diseases	13 (7.2%)	28 (11.3%)	38 (15.2%)	21(12.8%)	16 16.8%)	116 (12.4%)
Gastrointestinal Diseases	42 (2.2%)	4 (1.6%)	11 (4.4%)	7 (4.3%)	7 7.4%)	33 (3.5%)
Metabolic Disorders	19 (10.5%)	9 (3.6%)	21 (8.4%)	11 (6.7%)	2 (2.1%)	62 (6.6%)
Malignancy	21 (11.6%)	34 (13.7%)	33 (13.2%)	19 (11.7%)	12 (12.6%)	119 (12.7%)
Neurological Disorders	13 (7.2%)	14 (5.6%)	18 (7.2%)	15 (9.2%)	5 (5.3%)	65 (6.9%)
Renal System Disorders	11(6.1%)	7 (2.8%)	19 (7.6%)	11 6.7%)	7(7.4%)	55 (5.9%)
Premature Birth	0 (0%)	1 (0.4%)	1 0.4%)	3 (1.8%)	1 (1.1%)	6 (0.6%)
Other Causes	2 (1.1%)	14 (5.6%)	7 (2.8%)	4 (2.5%)	2 (2.1%)	29 (3.1%)
Infectious Diseases	12 (6.6%)	19 (7.6%)	21 (8.4%)	21 (12.8%)	6 (6.3%)	79 (8.5%)
Total	180 (100%)	247(100%)	249(100%)	163(100%)	95 (100%)	934(100%)

However, in many cases the cause of death mentioned was incomplete as shown in figure 3. Out of 934 cases, in 199 cases, the cause of death mentioned was incomplete. It was not as per WHO format of Medical Certification of cause of death.

Discussion

In the present study, the data regarding mortality over a period of 5 years from January 2014 to May 2018 was collected and analyzed. It revealed that there has been an overall decrease in the mortality rate over past5 years from 16.2 in 2014 to 9.5 in 2018. This finding is similar to that in a previous study conducted by Kauser et al. in Chitradurga, Karnataka.[1] But in a study conducted in Solapur, Maharashtra, India by Godale and Mulaje,[6] the mortality rate was static in their study of 5 years. The mortality rate reductions are attributed to better medical care, including high tech medical treatment. Smoking cessation and nutritious diet are also the

factors contributing to survival of the patient as they affect death from heart disease and from smoking-sensitive cancers. Rising incomes and a variety of social programs have accompanied significant reductions in mortality. Higher incomes make possible the use of expensive medical technology.[7]

In the present study it was found that mortality among men was higher than women in all the years. This observation is concordant with other similar studies by Kauser et al. and Deepak et al. in Karnataka[1-2], Godale and Mulaje in Maharashtra[6] and also correlates with Government Statistics on mortality.[2] This is probably due to biological, physiological and behavioral differences between male and female population, along with the influence of cultural and environmental factors. For instance, risk taking unhealthy behaviors such as cigarette smoking, heavy drinking, use of firearms and employment in hazardous occupations are more prevalent among males which accounts for their higher death rate due to lung cancer, accidents, suicide, and homicide as compared to females.[8]

The majority of deaths in these 5 years have occurred among people over the age of 60 years. Similar observations were made in a study conducted by Deepak et al. in Mysore.[2] This finding can be attributed to high prevalence of non-communicable diseases in this age group along with the burden of infections.[2] However, in contrast to our findings, maximum number of deaths occurred in the age group of 15 – 60 years in the studies conducted by Godale and Mulaje[6] (in Maharashtra) and Gowri Shankar and Kalburgi EB (in North Karnataka).[9]

The majority of deaths in our study were found to be due to Cardiovascular causes, similar to the findings in a previous study by MM Kauser[1] but opposing findings were made in a study by C Deepak et al. in Mysore[2]and Lata Godale and Sanjay Mulajein Solapur, Maharashtra.[6] This can be attributed to risk factors like Diabetes Mellitus, Hypertension, Smoking, Sedentary lifestyle, Obesity and Alcoholism being highly prevalent among the population in the study area.[2] The second and third highest numbers of mortality were caused due to Malignancy and Respiratory disorders followed by Metabolic and Neurological Disorders. The emergence of malignancy as one of the major causes of death was also evident in the Global Cancer report published by the World Health Organization.The increase in risk factors like Smoking, high calorie diet, infections like hepatitis B and HPV among women along with genetic factors(accumulation of mutations with aging) are held responsible.[10]The most common respiratory disease asthma is caused due to exposure to allergens in the outdoor or indoor environment, smoking, genetics, and lifestyle .The majority of deaths among infants have occurred in the first 24 hours of birth due to Preterm and extreme preterm birth, in keeping with the findings of a study conducted by DG Bassani et, al,[11] on nationwide causes of neonatal mortality. Majority of infant deaths occurring within 24 hours of birth can be attributed to prematurity, low birth weight, asphyxia, birth trauma and neonatal infections.

Mortality among people in rural areas was found to be greater than in urban areas. Previous study by MM Kauser and Godale and Mulaje,[6] also came up with similar findings. This may be due to poverty being more prevalent in rural areas and patients being referred from Primary Health Centers to Tertiary care hospitals in the end stages of their illness.[1]

The proportion of deaths due to non-communicable diseases (NCD) was found to be greater than communicable diseases as was also noted by Kauser et al. and Godale and Mulaje,[6] in their studies. This disturbing trend of rise in deaths due to NCDs was also noted in Global studies on NCDs published by the WHO.[12] Lack of physical activity, causing health problems related to cardiovascular systems and metabolism, along with the development of certain kinds of cancer, poverty, unbalanced diets which fail to supply the proper nourishment and nutrients, Abuse of tobacco and alcohol Environmental factors resulting from unsustainable practices and emissions that influence bodily function along with sluggishness on a global level, to promote measures that ensure a cleaner, healthier environment aid in the development of NCDs.[12]

Conclusion

In the present study, mortality was highest above the age of 60 years, which constitutes from14.0% to 8.3 %over the years and the major cause of mortality was cardiovascular diseases. Non-communicable diseases were most common which constituted for 90.7% of the deaths. This shows an increase in the life span of the population due to increase in quality of life and improved sanitary and hygienic conditions. But as it is a tertiary care hospital, it may not reflect the scenario in the field at a primary level but it does correspond to the general trends. There is also decreased mortality rate over time showing improved patient care and technology over the years, and increased number of patients having a positive outcome following admission. The cause of death has been entered incompletely in many cases. Training of doctors & MRD faculty with respect to cause of death writing and ICD classification according to system wise has to be done periodically for better documentation which will help in future for data collection.

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ORIGINAL ARTICLE

Effectiveness of histopathological examination in medicolegal autopsies – A four-year retrospective study from a tertiary level medical college hospital from South India

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Abstract
Histopathological examination (HPE) in medicolegal autopsies (MLA) is essential when gross examination is not sufficient to confirm or exclude morphological changes at cellular level. This study aims to evaluate the histopathological findings in medicolegal autopsies and determine the efficacy and effectiveness of HPE in MLA. A four years retrospective study was done from July 2015 to June 2019 and all cases of MLA which were sent for HPE to department of pathology were included in the study and clinical autopsies were excluded from the study. There were total of 364 cases with age range was between 0 to 86 years, with male female ratio of 1:1.09. Majority of the cases sent for HPE were for suicidal deaths by hanging which accounted 80.4% (293 out of 364 cases). Of autopsies done for cases other than suicidal hanging and strangulation, which were 63 cases, the most frequent organ submitted was heart (38 cases), followed by lungs (22 cases), liver(18 cases), kidneys (17 cases), brain (14 cases), spleen (13 cases), uterus (8 cases), intestine (6 cases), testes (2cases), pancreas and gall bladder (one case each). Overall significant findings were noted in any of the organs in 41 cases, did not show significant changes on microscopy in 7 cases, and showed autolysis in 15 cases. In our study HPE was more efficient in Lung (72.9%), followed by heart (36.3%). HPE plays an important role in establishing cause of death in MLA. It will be more fruitful when autopsy surgeon and histopathologist work together and autopsy surgeon clearly specifies what he is expecting or what he wants to exclude.

Keywords
Medicolegal autopsies; Gross findings; Histopathology; Suicidal hanging

Introduction

Autopsy is done for both clinical as well as medico-legal purposes.[1] Medicolegal autopsies (MLA) are usually performed by forensic expert whereas clinical autopsies are performed by pathologist; however, the procedure involved is same for both. Histopathological examination (HPE) in MLA is essential when gross examination is not sufficient to confirm or exclude morphological changes at cellular level.[2] However, several authors differ in their opinion about the usefulness of HPE in MLA, on whether or not it aids in establishing additional information.[2-5] Hence, we have taken up this study to review all cases of MLA which were sent for HPE during the study period to assess its usefulness.

Materials and Methods

This retrospective study was conducted over the medicolegal autopsy cases in the duration of 4 years between July 2015 and June 2019, after obtaining approval from the institutional ethics committee (IEC application no GMC/IEC/365/2020). The study was conducted on the visceral samples received by the department of Pathology for HPE following MLA. The MLA in and around Guntur district is conducted in area hospitals, community hospitals and tertiary hospital/medical college. The present study excluded samples received during clinical autopsies. The clinical details of the cases were retrieved from the forensic pathology records and inquest forms. The specimens submitted for histopathology were fixed in 10% neutral buffered formalin for 24 to 72 hours, later the tissues were processed in automated tissue processor (Lieca, model TP 1020) and embedding was done in paraffin.Three to five microns sections were cut using microtome (Lieca RM 2125RT) from the paraffin embedded tissue blocks. The sections obtained were stained with Haematoxylin and eosin (H&E) stain. All the slides were reviewed by the authors.

The cases were further stratified as “not-efficient”, “efficient but not effective” and “efficient and effective” as described by Jani et al.[2] The cases were categorised as “not-efficient”, when the specimen was autolysed or not reportable; it was categorised as “efficient but not effective”, when the specimen was processed and but did not reveal significant pathology on microscopy and was categorised as “efficient and effective when microscopy revealed significant HPE changes. Data entry was made in Microsoft excel sheet. Frequencies and percentages were calculated manually. Mean was calculated for continuous variables manually.

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Results

There were total of 364 cases which were sent for histopathology during the study period, of which few were cases of couple hangings and mother and child suicides. The age range was between 0 to 86 years, with male female ratio of 1:1.09 (females -174, males- 190). The cases sent for histopathology can be broadly categorised into following categories (Table 1). Suicide cases by hanging, to know whether ligature mark was antemortem or post-mortem, were 293 in number. Cases of sudden death to know the cause of death had accounted for ten cases. Cases of Suspicious death and the cases where the cause was not known, to know the cause of death, including cases of alleged medical negligence were 53 in number. Other 8 cases included four cases each of suicides by other means and murder by throttling.

Majority of the cases sent for HPE were for Suicidal deaths by hanging which accounted 80.4% (293 out of 364 cases). Skin over the neck was sent for HPE, to determine whether ligature was antemortem or post-mortem. Most common age group was between 21 to 30 years (97/293, 33.1%), followed by 31 to 40 (53/293, 18%) and 10 to 20 years (42/293, 14.3%), shown in Table 1. Male: female ratio is almost same, 147 cases and 146 cases respectively. On histopathology, autolysis was seen in 70 cases (24.2%), which is categorised as “not efficient”, eleven cases (3.7%) showed normal histology which are categorized as “efficient but not effective” and antemortem changes were seen in 211 cases (72%)(Figure 1) which are categorized as “efficient and effective.” Skin over neck was sent for HPE, in seven cases where foul play was suspected, including murder by throttling cases, or in cases where the cause of death was not known; of these, 50% cases showed, antemortem nature of lesion which are categorized as “efficient and effective” and other 50% were autolyzed, categorised as “not efficient.”

Of MLA done for cases other than suicidal hanging and strangulation, which were 63 cases, most frequent organ submitted was heart in 38 (60.3%) cases, followed by lungs in 22 (34.9%) cases, liver in 18(28.5%) cases, kidneys in 17 ((26.9%) cases, brain in 14 (22.2%) cases, spleen in 13 (20.6%) cases, uterus in 8 cases (12.6%), intestine in 6 (9.5%) cases, testes in 2(3.1%) cases, pancreas and gall bladder in one case (1.5%) each. Overall significant findings were noted in any of the organs in 41 cases (65%), which are categorized as “efficient and effective”, did not show significant changes on microscopy in 7 cases (11.1%) which are categorized as “efficient but not effective”, and showed autolysis in 15 cases (23.8%) categorised as “not efficient.” The heart was sent as part of multiple organs or singly in totally 38 cases, of which 28 cases were of suspicious or unnatural deaths and ten cases were of sudden deaths. The weight of the adult heart ranged between 125 to 550gm, with an average weight of 300gm. The left ventricular wall thickness ranged between 1 to 3 cm, with an average of 1.8cm. The right ventricular wall thickness ranged between 0.2 to 1.2 cm, with an average of 0.7cm. The interventricular septal wall thickness ranged between 0.6 to 3 cm, with an average of 1.6 cm. Significant changes were seen in 11 cases (Figure 2A to 2D), as shown in the table 2,3. Coronary artery disease (15.7%) (Figure 2B) was the most frequent significant finding in heart followed by ventricular hypertrophy (7.8%) and myocarditis (5.2%) (Figure 2D).

Brain was sent as part of multiple organs or singly in totally 14 cases, of which only one case (7.1%) showed significant finding of metastasis from testicular mixed germ cell tumour (Figure 2H), and rest of the cases (92.8%) did not show significant changes on microscopy. Lungs, either whole or part of lungs were sent as part of multiple organs or singly in totally 22 cases, of which significant changes (Figure 2E, F) are seen in 16 cases (72.7%) as shown in the Table 2 and 3, four of the cases (18.1%) did not show significant changes on microscopy and autolysed in two cases (9 %). Congestion (22.7%) was the most frequent significant finding in lung in our study followed by pneumonia and pulmonary oedema (Figure 2E) (18.1% each). Liver was sent as part of multiple organs or singly in totally 18 cases, of which significant changes are seen in 12 cases (67.3 %) which included, congestion in 3 cases, fatty change in 7 cases (Figure 2G), and inflammation in 2 cases. Six cases (33.3%) did not show any significant changes on microscopy. Gall bladder was sent in one case which showed calculous cholecystitis. Pancreas was sent in one case which showed chronic pancreatitis changes Spleen was sent as part of multiple organs or singly in totally 13 cases, of which one case showed congestion and other case showed haemorrhages, and rest of the cases did not show significant changes on microscopy. Intestines were sent in six cases, of which one case showed perforation, one case showed ulceration and inflammation, one case showed serosal inflammation, one case was normal, and two cases were autolysed. Kidneys were sent as part of multiple organs or singly in totally 17 cases, of which one case showed polycystic kidney disease and another case showed congestion and rest of the cases did not show significant changes on microscopy. Uterus was sent as part of multiple organs or singly in totally eight cases, to look for pregnancy changes. Pregnancy changes were seen in three cases, adenomyosis was seen in one case and rest of the cases did not show significant changes on microscopy. Testes was sent as part of multiple organs or singly in totally two cases, one case mixed germ cell tumour with brain and lung metastasis, and in the other case, testis was autolysed. In addition, neck structures were sent in two cases, of which one case showed Hashimoto's thyroiditis and other case was normal. Salivary gland included in neck skin in one case showed pleomorphic adenoma (Figure 2I).

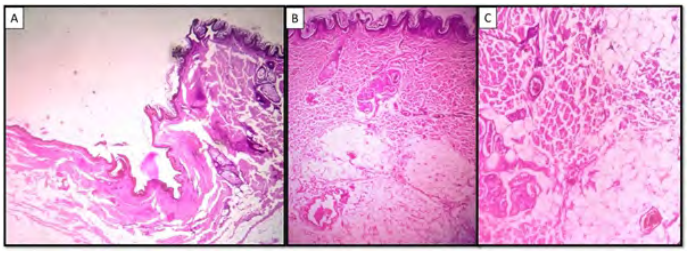

Figure 1: HPE of ligature site, A) H&E, 100X, skin and subcutaneous tissue showing compression, breaking, wrinkling B, C) H&E, 100X, 400x, subcutaneous tissue showing congestion of blood vessels and hemorrhage

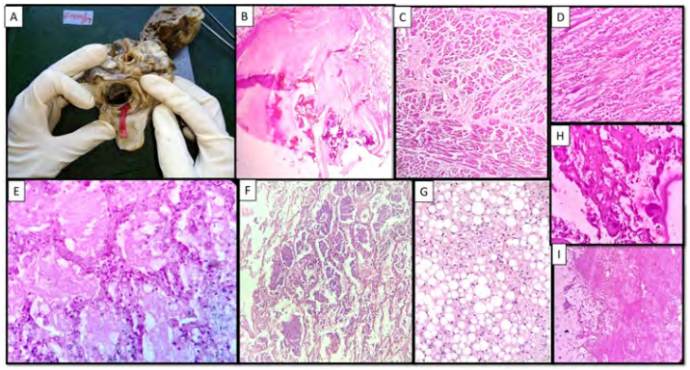

Figure 2: Gross picture of heart showing artificial valve with thrombosis B)to I) 100X, H&E, B)cross section of coronary vessel showing calcified atherosclerosis and luminal narrowing, C) Healed infarct of left inferior ventricular wall showing interstitial fibrosis, D) Myocarditis showing interstitial inflammatory infiltrate E)400X, H&E, Pulmonary edema with edema fluid in alveolar spaces F) Lung adenocarcinoma with pleomorphic neoplastic cells infiltrating lung parenchyma G) Liver showing fatty change, H) Brain showing metastatic tumor deposit of germ cell tumor, choriocarcinoma component, I) Salivary gland showing pleomorphic adenoma

Table 1: Age distribution of suicidal hanging cases

Age (years)	Death by hanging, (n= 292)	Cases of sudden death (n=10)	Cases of suspicious death and the cases where the cause was not known (n = 53)	Suicides by other causes (n=4)	Death by throttling (n=4)
0-10	3	0	3	0	0
11-20	42	0	11	0	0
21-30	97	1	12	1	2
31-40	53	3	5	1	0
41-50	22	2	6	0	0
51-60	16	0	3	0	0
61-70	5	1	4	0	0
71-80	3	0	2	0	0
81-90	1	0	0	0	0
unknown		3	7	2	2

Table 2: Pathological changes in heart and lung

Heart	N	Lungs	N
Coronary artery disease	6 (15.7%)	Metastatic deposits	1 (4.5%)
Valvular heart disease	1(2.6%)	Normal	4 (18.1%)
Myocardial infarction	1(2.6%)	Amniotic fluid aspiration	1 (4.5%)
Myocarditis	2(5.2%)	Hyaline membrane disease	2 (9%)
Ventricular hypertrophy	3(7.8%)	Pulmonary oedema	4 (18.1%)
Pericardiac cyst Fibrin clot in LA	1(2.6%) 1(2.6%)	Pneumonia	4 (18.1%)
No light microscopic changes	17(44.7)	Congestion	5 (22.7%)
Autolysis	8 (21%)	Autolysed	2 (9%)

Table 3: Significance of HPE in various organs

Organ	"not-efficient"	"efficient but not effective"	"efficient and effective"
Heart (n=38)	8(21.1%)	17(44.7%)	11 (28.9%)
Lung (n=22)	2(9%)	4(18.1%)	16 (72.7%)
Liver (n=18)	0	6(33.3%)	12(67.3%)
Brain (n=14)	0	13 (92.8%)	1(7.1%)
Spleen (n=13)	0	11 (84.7%)	2(15.3)
Kidney (n=17)	0	15 (88.2%)	2(11.8%)
Intestines (n=6)	2(33.3%)	1(16.7%)	3(50%)
Uterus (n=8)	0	4(50%)	4(50%)

Discussion

Though several authors[2-5] differ in their opinion on whether or not HPE of MLA is required and whether it adds any additional information, we found in our study that HPE plays a valuable role in confirming or excluding the queries raised and also in determining the cause of death. We have also found few incidental additional findings during the HPE.

Hanging is one of the common methods for suicide in India[6]. Skin over the neck in suicidal hanging cases was the most common specimen (80.4%) received for HPE in MLA cases. It is also sent in strangulation cases. The cause and manner of death in majority of the hanging cases can be made through thorough medicolegal examination, inquest report, circumstantial evidences present at the scene of incident. HPE is seldom necessary to opine the cause of death. Only in suspicious cases histopathology examination of the skin having ligature mark can be done to confirm antemortem or post-mortem nature of suspension. HPE plays a crucial role in such circumstances in establishing whether the ligature mark is antemortem or post- mortem. The characteristic histopathological changes seen in skin of ligature mark are compression, breaking, wrinkling, congestion, haemorrhage and cellular infiltration. However, the limitation of HPE is, the absence of these changes does not exclude antemortem hanging.[9] So HPE is helpful in confirming antemortem nature of ligature mark, but not in

excluding it. HPE was efficient and effective in 72% of our cases. In 24.2% the specimen was autolysed, as it was not sent in formalin; in many of such cases, the specimen was sent in salt or saline, this was more common in cases received from peripheral hospitals. So, the problem was not with HPE.

The most common age group for suicidal hanging in our study was between 21 to 30 years (33.1%) Yadav & Gupta[6] had also made similar observations, 45.05% of their cases were between the age group of 21- 30 years. Luke et al[8] have observed that 26% of their cases belonged to the same age group. Yadav & Gupta[6] and Luke et al[8] have found, male predominance in their studies; however, we have found equal sex predilection in our study. This might be because we had higher number of dowry deaths which has increased the proportion of female suicides.

In present study, of MLA done for cases other than suicidal hanging and strangulation, HPE was efficient and effective and showed significant findings in any of the organs in 65% of cases. Pathak and Mangal[1] could identify the cause of death in 82.22% of their cases by correlating HPE with history, inquest papers and post-mortem findings and could not be establish cause of death in 17.78% cases. The relative lesser percentage of HPE being effective in the present study is due autolysed specimens rather than limitation of HPE.

In our study, HPE was more efficient in Lung (72.9%), followed by heart (36.3%) whereas Jani et al[2] observed that HPE were more efficient in Uterus, Heart and Brain. Pathak and Mangal[1] found maximum pathology in Cardio-Vascular System (40% cases) and in Respiratory System (30% cases). Though HPE was more efficient in lung in present study, the most common finding in the lung was congestion; but presence of congestion does not make any difference in ascertaining the cause of death. Similarly, in heart the most common pathology found in heart in present was ventricular hypertrophy which may or may not contribute to death. But presence of other findings like coronary artery disease, myocarditis and myocardial infarction in heart helps ascertain the cause of death. Therefore, HPE will be helpful in ascertaining the cause of death, when autopsy surgeon sends viscera for HPE, when he or she finds any abnormality grossly and suspects it to be the cause of death.[10] Likein one case of custodial death in our study, the autopsy surgeon suspected testicular tumour with lung and brain metastasis grossly during autopsy and submitted testis, brain and lungfor HPE, which where subsequently confirmed as germ cell tumour of testis with lung and brain metastases on HPE. HPE will be of more help in such instances either by confirming or negating the suspicions of autopsy surgeon. Molina et al[5] opined that HPE will not determine the manner of death and will change the cause of death in less than 1% of cases. Jani et al[2] have enumerated various factors that determine the effectiveness of HPE in MLA like purpose of HPE; taking representative sections from the organs concerned; type of stain used and interpretation of the available data.

HPE is more effective when it is done to confirm the cause of death, or when it is done to look for specific findings like whether ligature mark is antemortem or post-mortem or either pregnancy changes are present or absent in uterus followed by instances where it is done to look histopathological changes in unknown and unnatural causes of death. In addition, any incidental new findings on HPE may help in establishing the cause of death or merely help in increasing our knowledge and gathering mortality statistics which are necessary in health service planning.[10]

Conclusion

HPE plays an important role in establishing cause of death in MLA. HPE will be more fruitful when autopsy surgeon and histopathologist work together and autopsy surgeon clearly specifies what he is expecting or what he wants to exclude.

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Conflict of interest: None to declare

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ORIGINAL ARTICLE

An Autopsy Based Study about Epidemiological Profile of Deaths Due To Hanging in Central India Region, Madhya Pradesh

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Abstract
This is a 1 year autopsy based prospective study carried out on cases of death due to hanging in mortuary of Department of Forensic Medicine & Toxicology, Mahatma Gandhi memorial Medical College and M.Y. Hospital, Indore, (M.P.) between February 2019 and January 2020. In our study, 172 cases (134 males & 38 females) of death due to hanging brought for medico legal post mortem examination were taken. The most common age for hanging is found to be between 21-30 years in 36.63% cases. Hindus constituted 93.02% of total study population. 57.56% were married and 42.44% cases were unmarried. Hanging deaths occurring in urban areas (83.14%) outnumbered that of rural area (16.86%). 45.35% cases had completed their secondary education. 61.04% incidences happened in nuclear families. Students (30.81% cases) and self employed persons (30.81% cases) constituted more than half of total cases. Majority of victims (72.09% cases) in this study belonged to the middle class socio-economic group, with 19.77% brought in on Wednesday followed by Sunday in 16.86% cases. In our study, majority of victims were found at night time (in 36.63% cases) followed by early morning (in 25.0% cases). 95.93% cases were found hanging at indoor locations.

Keywords
Hanging; Epidemiological profile; Socio-economic group.

Introduction

Death is a constant for the living, but it is only the humans who tend to end their lives earlier than destined by committing suicide. Human suicidal behavior has always been a source of dread and wonder to mankind. Suicide is the deliberate act of taking one's own life, but suicide is merely the outcome, which is a result of a multi-factorial process and has biological, genetic, psychological, sociological factors associated with it.[1]

Hanging is that form of asphyxia which is caused by suspension of the body by a ligature which encircles the neck, the constricting force being the weight of the body.[2] Hanging is most commonly suicidal followed by accidental, only exception to which is 'lynching'**.** It is also the method of capital punishment adopted by Indian legislature. There have been instances wherein the subject was hanged postmortem i.e., the person was killed in some other way and later suspended to simulate hanging. As is evident from the aforementioned points, hanging is one of the most complex and controversial zone of asphyxial deaths. To ascertain cause and manner of death in cases of hanging, detailed history from the relatives of deceased is essential and other autopsy findings are of utmost importance. [3]

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Present study is an attempt to describe the socio-demographic pattern of hanging as well as the place of the incidence in central India region in Madhya Pradesh.

Material and Methods

The present study is a prospective study carried out on a sample of 172 cases of deaths due to hanging in mortuary of Department of Forensic Medicine & Toxicology, Mahatma Gandhi memorial Medical College and M.Y. Hospital, Indore, (M.P.) between the study duration of February 2019 to January 2020. The details regarding history of the incidence, personnel details of the deceased and post mortem findings were recorded on specially designed proforma to compile the information and analyze the same to obtain the epidemiological profile of cases of deaths due to hanging in this region.

Results

A total of 172 cases of death due to hanging were taken into consideration during this period of study and on eliciting the detailed history from the police and relatives of the deceased, several criteria related to the epidemiological profile of deceased due to hanging were taken in detail in this study, as follows :-

The most common age for hanging was found to be between 21-30 years, wherein 63 (36.63%) deaths occurred. The next most vulnerable age group was 31-40 years in which 41 (23.84%) deaths occurred. In 11-20 years age group, 31 (18.03%) deaths occurred. In 41-50 years age group, 22 (12.79%) deaths occurred. In old age, i.e. after 61 years,

incidence came down to 2.32% i.e. only 4 deaths. [Table 1]

On sex wise distribution of study population, 134 (77.91%) cases were males and 38 (22.09%) cases were females. Males far outnumbered the females in this study.

It was observed that, out of entire sample population, 160 (93.02%) cases were Hindus followed by 6 (3.48%) Muslims, 4 (2.33%) Sikhs and 2 (1.16%) Christians. [Table 2]

Out of 172 cases, 99 cases (57.56%) were married and 73 cases (42.44%) were unmarried. Hanging deaths occurring in urban areas i.e. 143 cases (83.14%) outnumbered the deaths happened in rural areas, i.e. 29 cases (16.86%).

78 (45.35%) cases had completed their secondary education, 45 (26.16%) cases had primary education, and 21 (12.21%) cases were illiterates. 19 graduates (11.05%) and 9 post graduates (5.23%) have also been found in the present study as hanging victims. [Table 3]

Table 1: Distribution of the study population according to age (N=172)

Age in years	N	%
< 10	0	0
11-20	31	18.03
21-30	63	36.63
31-40	41	23.84
41-50	22	12.79
51-60	11	6.39
61-70	2	1.16
>70	2	1.16

Table 2: Distribution of the study population according to the religion (N=172)

Religion	N	%
Hindu	160	93.03
Muslim	6	3.48
Sikh	4	2.33
Christian	2	1.16

Table 3: Distribution of the study population according to educational status (N=172)

Educational status	N	%
Illiterate	21	12.21
Primary	45	26.16
Secondary	78	45.35
Graduate	19	11.05
Postgraduate	9	5.23

Table 4: Distribution of the study population according to their occupation (N=172)

Occupation	N	%
Farmer	11	6.39
Self employed	53	30.81
Student	53	30.81
Housewife	20	11.62
Employed (govt./priv.)	25	14.53
Unemployed	10	5.81

Table 5: Distribution of the study population according to the Day of Incident (N=172)

Day of incident	N	%
Sunday	29	16.86
Monday	23	13.37
Tuesday	21	12.21
Wednesday	34	19.77
Thursday	24	13.95
Friday	20	11.63
Saturday	21	12.21

Table 6: Distribution of the study population according to the Time of Incident (N=172)

Time of incident	N	%
Early morning	43	25.00
Morning	17	9.88
Mid-day	13	7.56
Evening	36	20.93
Night	63	36.63

People living in nuclear families accounted for 105 (61.04%) cases whereas those living in joint families accounted for 67 (38.95%) cases in present study.

While comparing the occupational status of the deceased by hanging; 53 (30.81%) cases were students and 53 (30.81%) cases were self employed persons. Govt./Private employee accounted for 25 (14.53%) deaths followed by 20 (11.62%) deaths of House wives. 11 (6.39%) cases were farmers. Unemployed persons also accounted for 10 (5.81%) deaths. [Table 4]

In our study, socioeconomic status of all the cases was assessed on the basis of Modified Kuppuswamy scale. Majority of the victims of hanging were from middle class socio-economic status i.e. 124 cases (72.09%). 31 (18.03%) cases belonged to lower class and 17 cases (9.88%) belonged to upper class socio-economic group. 34 (19.76%) cases chose Wednesday to

commit hanging, followed by 29 (16.86%) cases on Sunday and 24 (13.95%) cases on Thursday. Monday accounted for 23 (13.37%) hanging deaths. Tuesday and Saturday accounted for 21 (12.20%) deaths each and Friday accounted for 20 (11.6%) cases of hanging. [Table 5]

63 (36.63%) cases in this study population found night as most convenient time for hanging themselves, followed by early morning in 43 (25.00%) cases. 36 (20.93%) cases hanged during evening hours, whereas 17 (9.88%) cases in morning and 13 (7.56%) cases during mid-day hours. [Table No. 6]. In the present study, we found that out of 172 cases, 165 cases (95.93%) hanged themselves in indoor locations like bedroom, hall, kitchen or drawing hall, where as only 7 cases (4.07%) hanged at outdoor locations like farm or forest.

Discussion

Age:- The most vulnerable age for hanging is found to be between 21-30 years, wherein 36.63% deaths occurred, followed by the next most vulnerable age group 31-40 years, in which 23.84% deaths occurred. Among youth, increased suicidal rates may be due to modern social disorganization, increasing expectations from life with increasing job and study competition. Frustration and breakdown in this age group is more commonly seen due to lack of patience, failures at jobs, financial instability, tortures for dowry, failures in love affairs and domestic disputes.

Studies conducted by Abouhashem Aisha A. et al[4]; Ahmad M, MZ Hossain[5]; Patel A.P. et al[6]; MV P.K. and Rayamane A.P[7]; Sadikhusen G. Momin et al[8] found most common age group committing suicide by hanging to be 21-30 yrs. Whereas, this is in contrast with the studies conducted by Mishra PK et al[9]; Elfawel MA and Awad OA[10], who found most common age group committing suicide by hanging to be 30-39 years.

Sex:- Out of 172 cases of hanging from January 2019 to December 2019, 77.91% are males and 22.09% are females. Males far outnumbered the females in the present study. Due to the fact that males are expected to bear more social and family responsibilities which cause more mental stress and agony, they might have been reported more as hanging victims.

Similar findings were observed in the studies conducted by B. R. Sharma, D Harish, Virendar Pal Singh, Preminderjeet Singh[11] (Males 68% & Females 32%); DS Badkur et al[12] (Males 68% & Females 32%); Ali E et al[13] (Males 69.2% & Females 30.8%), Nawal Kumar singh et al[14] (Males 72% & Females 28%), Sharija S and Shreekumari K[15] (Males 71.27% & 28.72%), Mishra PK, Tomar JS, Varun A, Verma P[9] (Males 68.14% & Females 31.86%).

It is in contrast to the findings observed by M Ahmad, MZ Hossain[5] (Males 41.37% & Females 58.62%); and M Ahmad, F N Rahman, M A Hussain, M H Chowdhury, B H N Yasmeen[16] (Male 72.29% & Female 27.71%).

Religion:- In the present study, it was observed that, out of entire study population, Hindus were 93.02% followed by Muslims 3.48% and Sikh 2.33%. Similarly MR Nagendra Gouda et al[17] found Hindus 94.6% and Muslims 5.4 % as hanging victims. Chetan kumar et al[18] found Hindus 93%, Muslims 5%, Christians & Sikhs 2% as cases who committed suicide by hanging.

Marital status:- In this study, 57.56% cases were married and 42.44% cases were unmarried. Similar findings were observed in the study conducted by Ali E. et al[13] (Married 56%, Unmarried 40% & Unknown status 3.3%); M Ahmad et al[16] found 51.03% married and 48.96% unmarried; MR Nagendra Gouda et al[17] found 62.4% married and 33.9 % unmarried cases committed suicide by hanging themselves. It is in contrast to the findings observed by B.S. Chavan et al[19] in which, unmarried cases outnumbered the married cases, i.e. 57.4% of the subjects were unmarried, and 40.5% of the subjects were married in their study.

Place of Residence:- Hanging deaths occurring in urban areas (83.14% cases) outnumbered than that of rural area (16.86% cases). More cases of hanging suicides from urban region may be due to the fact that there is a constant rush for livelihood and existence in these areas with ever growing day to day lifestyle stress. In studies conducted by Mishra PK et al[9] 85.84% of study population belonged to Urban region and only 14.16 % cases were from rural areas. Similarly Chetan kumar et al[18] found 95.04 % of their study population was from urban region and 4.95% cases were from rural area.

In contrast, the study conducted by Nagendra gouda et al[17] found 70.6 % of hanging cases were from rural region and 29.4% of cases were from urban areas.

One reason for more number of cases in our study from urban areas is due to the fact that most of the hanging cases coming to our mortuary were from urban regions.

Educational status:- Role of education in unnatural deaths like hangings is an important factor to be noticed. Out of 172 cases, 45.35% cases had completed their secondary education, 26.16% cases had primary education, and 12.21% cases were illiterates. Even graduates (11.05%) and post graduates (5.23%) have been found as hanging victims in the present study. In study conducted by MR Nagendra Gouda et al[17], 27.4% cases were illiterate and 52.2% cases had completed their high school. The study conducted by Ali E. et al[13] found 51.8 % illiterates, 23.1% cases with primary education, 20.1% cases with SSC education and 1.8% cases with HSC education. Samanta AK et al[20] did a study including 45.7% illiterates, 38.10% cases with high school education and 15.23% cases with graduation.

Type of Family:- People living in nuclear families (61.04%)

outnumbered those living in joint families (38.95%) in present study. This may justify the reason for elders to console the youngsters and help each other in tough times rather than leaving them in loneliness, which may become the prime cause for suicide.

Observations made in the studies conducted by MR Nagendra Gouda et al[17] (Nuclear family 53%, Joint Family 33.1% & 11.7% families with 3 generations), Ali E. et al[13] (Nuclear family 76.0 % & Joint family 24.0%) and Chetan kumar et al[18] (Nuclear family 73.26 %, Joint family 20.0% & 6.0 % alone) showed that victims belonging to the nuclear families far outnumbered to those living in joint families.

Occupation:- While comparing the occupational status of the deceased by hanging; majority were students (30.81% cases) and self employed persons (30.81% cases) constituting more than half of total cases. Govt./Private employees accounted for 14.53% of deaths followed by House wives accounting for 11.62% of deaths by hanging. Unemployed persons also accounted for 5.81% deaths. With up growing educational competitions or failures even after hardest and fullest possible efforts, students may tend to kill themselves more likely than other groups of this study.

Study by Samanta AK et al[20] found 30.48% cases of suicide by hanging were laborers, 20% were housewives, 18% were business class persons, 16% of cases were in different services and 14.3% were students.

MR Nagendra Gouda, Sambaji M Rao[17] found 75.0 % cases in their study were farmers. Pradeep Kumar M.V. & Anand P. Rayamane[7] found 38.0% of cases in their study been home makers and 38.0 % were semi skilled workers. The study conducted by Bhosle SH et al[21] included farmers (30.12% cases), Laborers (24.10%), Housewives (10.84%), students (10.84%) and servicemen (9.64% cases).

Socioeconomic status:- In our study, socioeconomic status of all the cases were assessed on the basis of Modified Kuppuswamy scale. Majority of the victims of hanging i.e. 72.09% cases were from middle class socio-economic status; lower class victims occupied 18.03% of deaths; and 9.88% cases belonged to the upper class socio-economic group.

Observations made in the study conducted by Ali E. et al[13] were similar having majority of victims from middle class (78.1%) followed by lower class (16.5%) and upper class (2.1%). Chetan kumar et al[18] had 62.37% cases from middle class, 25.75% cases from lower class and 10.09% cases from upper class.

Day of incidence:- Most of the people in our study population chose Wednesday (19.76% cases) to commit hanging, followed by Sunday (16.86% cases) and Thursday (13.95% cases). Relatively higher number of hangings were observed mid week. The accumulated level of stress both mental and physical may have an overwhelming effect over the number of suicide cases, thus making the victims more susceptible to emotional breakdowns as a consequence of which they may have taken extreme measures of self harm.

Time of Incidence:- 36.63% of hanging victims in our study found night as most convenient time for hanging themselves, followed by early morning in 25.0% cases. The vicious cycle of anxiety followed by sleeplessness over a period of time explains why many of hanging victims chose to hang themselves at night closely followed by early morning.

Similar findings were observed in the studies conducted by M Ahmad, MZ Hossain[5] (Night 69.65% & Day time 30.34%); Vijayakumari N[22] (50.8% deaths in early hours of the day); Abd Alkareem Q. Mohammed[23] (80% cases hanged between 3:00 PM and 3:00 AM).

Place of occurrence:- 95.93% cases hanged themselves in indoor locations like bedroom, hall, kitchen or drawing hall, where as only 4.07% cases hanged at outdoor locations like farm or forest.

Abouhashem AA et al[4] found 83.3% cases in their study hanged in indoor places and 16.7% cases hanged at outdoor places. Ahmad M et al[16] studied 97.93% cases of indoor hanging and 2.06% cases of outdoor hanging victims. Study conducted by Patel AP et al[6] also found 96.25% cases hanged in indoor places and 3.75% cases in outdoor places.

Conclusion

Age group of 21-30 years constituted maximum number (36.63%) of hanging victims followed by 23.84% cases in age group 31-40 years. Number of males (77.91%) committing suicide by hanging is far more than females (22.09%). Hindus constituted 93.02% of total study population followed by Muslims (3.48%) and Sikhs (2.33%) among all the hanging victims. Married people (57.56%) are more commonly taking their lives than unmarried people (42.44%) by hanging. Hanging deaths most commonly occurred in urban areas (83.14%), and from middle class socioeconomic group (72.09%). 45.35% cases had completed their secondary education followed by 26.16% cases having education up to primary schooling. 61.04% incidences happened in nuclear families, whereas 38.95% in joint families. Students (30.81%) and self employed persons (30.81%) were found to be most tender group for hanging followed by those employed in govt. / private jobs (14.53%). Most people chose mid week days to hang themselves with Wednesday being the day taking most of the lives out of all the days in a week in 19.77% cases followed by Sunday in 16.86% cases. In our study, majority of victims found night time (in 36.63% cases) followed by early morning (in 25.0% cases) as the most preferable time to hang

themselves. 95.93% cases were found hanging at indoor areas like bedroom, hall or drawing room whereas only 4.07% cases were found hanging at outdoors like forest/terrace.

Ethical clearance: A prior approval was obtained from institutional ethical committee.

Conflict of interest: None to declare

Source of funding: None to declare

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ORIGINAL ARTICLE

Grading and occurrence of coronary artery stenosis in different age groups-an autopsy based study

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Abstract

Cardiovascular diseases especially ischemic heart disease is the most frequent cause of sudden and unexpected death that constitute a considerable portion of the autopsies conducted in our country. The most common cause of sudden death all over the globe is of cardiovascular origin. The peculiarity of heart disease in Indian population compared to other parts of the globe is that its onset is 5-10 years earlier. Sudden deaths in younger age groups have become a major concern. The extent and severity of atherosclerosis with stenosis is the most frequent pathological lesion which develops to coronary artery disease. Coronary artery disease will soon emerge as the single largest disease accounting for nearly one-third of all deaths in India. Cases of sudden death, road traffic accidents, burns, poisoning and asphyxia brought to the mortuary of Sri Ramachandra Medical College and Research Institute, Chennai for postmortem examination during the period of September 2014 to September 2015, were studied in detail. Age group between 61-70 years had severe stenosis of 70-99% with 6 cases while age group of 31-40, 41-50, 51-60 years had severe stenosis of 70-99% with 3 cases each and confirmed by histopathological examination. Regular health checkup with cardiovascular screening must be recommended every 6 months from the age of 21 years to prevent the menace of cardiovascular diseases.

Keywords

Cardiovascular diseases; Coronary artery disease; Age groups; Sudden Death; India.

Introduction

The most common cause of sudden death all over the globe is of cardiovascular origin. More than 17 million people died from cardiovascular diseases in 2008. More than 3 million of these deaths occurred before the age of 60 years.[1]

10% of all deaths are sudden and unexpected deaths.45 to 50% sudden deaths involve the cardiovascular system. About 80% of cardiovascular deaths are myocardial infarction due to coronary artery atherosclerosis[2]with stenosis of the coronary arteries.

An estimated 17.5 million people died from cardiovascular diseases in 2012, representing 31% of all global deaths. Of all the global deaths in 2012, 31% were due to cardiovascular diseases, estimated to be about 17.5 million.

The peculiarity of heart disease in Indian population compared to other parts of the globe is that its onset is 5-10 years earlier and hence the complications may occur in the age group of 35-65 years, who are the backbone of our country's economy.

Sudden deaths in younger age groups have become a major concern as numerousstudies indicate that atherosclerosis has become a contributing factor for diseases of Cardiovascular system.

The main underlying pathological processes that lead to ischemic heart disease is coronary artery atherosclerosis with stenosis. The process of atherosclerosis can start in childhood and adolescence due to the cumulative effect of its risk factors.The risk factors include unhealthy diet, tobacco use, physical inactivity, obesity, use of alcohol, hypertension, diabetes, raised blood lipids, poverty, low educational status, advancing age, genetic predisposition and psychological factors.[3]

The incidence of coronary artery disease has increased more than twice in the last 30 to 40 years. Coronary artery disease will soon emerge as the single largest disease accounting for nearly one-third of all deaths in India. A total of nearly 6.4 crores cases are likely to be diagnosed with cardiovascular diseases of which 96% will be coronary artery disease.

The projected death from coronary artery disease by 2015 is 2.95 million of which 14% will be less than 30 years and 31% will be less than40 years.[4]

So, the most common cause of sudden death is of cardiovascular origin dominated by coronary artery disease. This adds to a quite large number of medico-legal autopsies done in the mortuary of Department of Forensic Medicine in India.

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Materials and Methods

Cases of sudden death, road traffic accidents, burns, poisoning and asphyxia brought to the mortuary of Sri Ramachandra Medical College and Research Institute, Chennai for postmortem examination during the period of September 2014 to September 2015, were studied in detail.

Before proceeding with the study, permission from the institutional ethics committee was obtained for research purpose to use human tissue samples.

Following detailed explanation about the study design, a written consent was obtained from the patient's blood relatives and documentation was done. Cases showing decomposition changes and relatives who did not give consent for the purpose of research were excluded.

Detailed examination of the heart was performed. Heart was removed from the pericardial sac and examined. The coronaries and their branches were examined individually. This was done by using a sharp scalpel and cutting transverse sections of the coronaries and their main branches at 3 mm intervals.[5,6] Arteries examined included the left main, the left circumflex, the left anterior descending, the right main and the right posterior descending. The coronary arteries were then examined for the degree of stenosis, presence of thrombus, calcification or haemorrhage into an atheromatous plaque. Left anterior descending coronary artery was given utmost importance in each case during dissection. The concerned tissue specimens were sent to Department of Pathology of Sri Ramachandra Medical College and Research Institute for histopathological examination to note the type of atherosclerosis.

Data were analyzed using computer software, Statistical Package for Social Sciences (SPSS) version 11.5. Data were expressed in its frequency and percentage. All the above details and findings were documented in the concerned proforma prepared for this study.

Results

A total of 62 cases done between September 2014 to September 2015were included in the study and grading of coronary artery stenosis was done after which the tissues were subjected to histopathological examination for further analysis. Of the 62 cases subjected for autopsy, 16 cases (25.8%) showed 70-99% stenosis, 8 cases (12.9%) showed 50-69% stenosis, 5 cases (8.1%) showed 25-49% stenosis and 12 cases (19.4%) showed <25% stenosis. Absence of stenosis was noted in 21 cases (33.8%). Age group between 61-70 years had severe stenosis of 70-99% with 6 cases while age group of 31-40, 41-50, 51-60 years had severe stenosis of 70-99% with 3cases each and confirmed by histopathological examination.

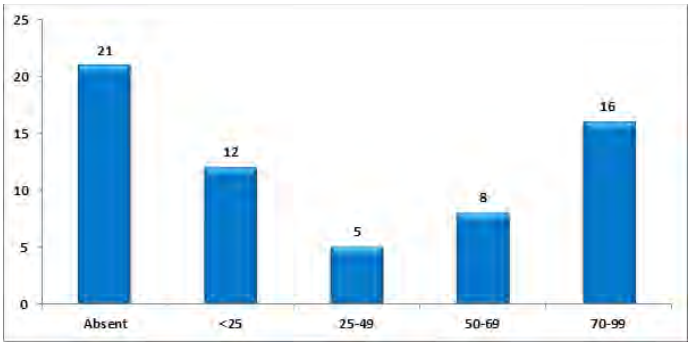

Figure 1: Grading of stenosis

Table 1: Grading of coronary artery stenosis

Stenosis percent	Number of cases(n=62)	Percentage (%)
Absent	21	33.8%
<25	12	19.4%
25-49	5	8.1%
50-69	8	12.9%
70-99	16	25.8%

Table 2: Age group and grading of stenosis

Stenosis %	21-30 years (n=14)	31-40 years (n=16)	41-50 years (n=11)	51-60 years (n=12)	61-70 years (n=7)	71-80 years (n=2)
Absent	9	8	1	2	1	0
<25	3	2	3	4	0	0
25-49	2	0	3	0	0	0
50-69	0	3	1	3	0	1
70-99	0	3	3	3	6	1

Table 3: Recommended quantitative stenosis grading by American college of cardiology foundation[7]

Descriptive Lumen Obstruction	Quantitative Stenosis Grading
Normal	Absence of plaque/no luminal stenosis
Minimal	<25% stenosis
Mild	25-49% stenosis
Moderate	50-69% stenosis
Severe	70-99% stenosis

Discussion

In his study,M-L Kortelainen[8]modified the grading of coronary artery stenosis to the following scale, as the narrowing percentages were often expressed as under/over 50%: 0

=normal coronary artery, no lesions; 1 = plaques causing luminal narrowing of under 50%; 2 = plaques causing luminal narrowing of 50%; 3 = plaques causing luminal narrowing of over 50%; 4 = plaques causing total occlusion of the lumen.

He observed that maximum number of cases had more than 50% stenosis and a considerable number of massively obese people seem to have coronary arteries without any advanced lesions or severe stenosis, even at an advanced age. As this was a study which included a variation of cases apart from sudden death, Coronary artery stenosis was found in equal ratio from the age of 20 years. Similar study with special preference to sudden death in a large sample along with the measurement of actual dimensions of the vessels may go a long way in ascertaining causative effect of coronary artery stenosis and deaths in different age groups.

Conclusion

Coronary artery atherosclerosis is the predisposing factor for myocardial infarction. Atherosclerosis with stenosis starts at the young age of 21 years proving that cardiovascular causes are the most common in sudden death. General public should be educated regarding the risk factors for atherosclerosis, coronary artery stenosis and myocardial infarction with lifestyle modifications. Regular health checkup with cardiovascular screening must be recommended every 6 months from the age of 21 years to prevent the menace of Cardiovascular Diseases.

Ethical clearance: A prior approval was obtained from institutional ethical committee.

Conflict of interest: None to declare

Source of funding: None to declare

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ORIGINAL ARTICLE

A prospective study on the pattern of traumatic ocular injuries in Central Karnataka and their forensic aspects

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Abstract

Total or partial blindness is a serious public health issue that affects a person's quality of life. Ocular trauma is one such leading cause of blindness, especially monocular blindness. Ocular injuries hold forensic importance when there is a significant loss in visual acuity as a result of an unnatural cause and expert opinion is needed to establish causation between the nature and extent of permanent impairment and injury. The prospective study conducted at a teaching hospital from January 2019 to December 2019, involving 48 cases, aims to analyse the pattern of traumatic ocular injuries and emphasize on the forensic issues involved. There was a preponderance of male patients (64.5%) over the female patients. 75% of cases were from the rural population and the common age group affected was 21-30 years among both sexes. Maximum injuries were inflicted at home (47.91%).Road traffic accidents (29.16%) were the most common mode of accidental injury. Closed globe injuries were seen in 22 cases (45.83%) and open globe injuries in 8 cases (16.66%). Permanent and partial loss of vision was seen in 22 cases of ocular trauma. Permanent and complete loss of vision was seen in one case. Ocular traumas are preventable through public awareness programmes and strict legislation for the use of personal protective devices that can help reduce the occurrence of such injuries. The study indicates that there is an urgent need to step up safety precautions to prevent disabling eye injuries and enlightens health care workers on the medico legal issues involved.

Keywords

Disability; Grievous injury; Medico-legal issues; Ocular trauma

Introduction

Ocular trauma is a primary cause of visual morbidity and monocular blindness.[1]The presentation of ocular trauma to the emergency room or the eye clinic may vary from minor injuries like subconjunctival haemorrhage to perforating injuries with potentially blinding consequences. Traumatic ocular injuries could be in the form of contusion or lacerations surrounding the eyeball, chemical burns, penetrating trauma, perforating trauma, penetrating or perforating trauma with intraocular foreign body accompanied by partial or total loss of visual acuity. Ocular injuries hold forensic importance when there is significant loss in visual acuity and when an injury to the eyeball occurs as a result of a negligent act, occupational hazard, traffic accidents, assault, fireworks and sports related activities. The consequences have many facets including legal, social and economic. Expert opinion is generally needed to establish causation between the nature and extent of permanent impairment and the injury.[1]The injury certificate or the medico legal report thus documented in such cases form the basis of medical evidence in the Court and hence demands a meticulous professional examination along with a structured, detailed, accurate and unbiased report.[2]

The epidemiology of ocular trauma varies in different parts of the world and can be diverse depending on the culture, habitat, risk factors and occupation in that geographic area. However, there is a dearth of literature on the epidemiological data of medico legal cases in Ophthalmology in large parts of the world.[3] Few studies have been conducted on ocular injuries following road traffic accidents, work related eye injuries and assault.[4-7,9] Even though ocular injuries do not figure among blindness control programs in India, the impact of ocular trauma in terms of the need for medical care, loss of income and cost of rehabilitation services clearly points towards the strengthening of preventive measures worthwhile and the studies have acknowledged that with the knowledge of circumstances of injury, their nature and damage caused, early appropriate management can be taken and preventive measures may be advised.[10,11] In India, National blindness and visually impaired survey conducted in 2019 reveal that the prevalence of blindness and visual impairment is 0.36% and 2.55% respectively.[12] Sadly there is no data on the percentage of blindness and visual morbidity as a result of ocular trauma. This may be owing to the facts that in an Indian scenario, considering a majority of ocular traumas arise from accidents and its association with head injuries or systemic injuries, it is

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seen as a clinical rather than a public health issue. Even the lack of reliable and good quality national or regional data registry has thwarted recognition of injuries as a public health problem in India.[13]

Since there have been studies conducted on ocular trauma and not many have highlighted the forensic issues involved, the authors, in the present study, have made an attempt to analyse the pattern of traumatic ocular injuries in the region of Central Karnataka and emphasize on the medico legal issues that arise from a forensic purview.

Materials and Methodology

The present prospective study was conducted at a medical college teaching hospital in Central Karnataka on 48 cases of traumatic ocular injuries presenting either to the emergency room directly or to the department of Ophthalmology during the period of 1 year, i.e from January 2019 to December 2019. An approval from the Institutional Ethics Committee was obtained for the study. The study included all such cases in the age range from 5 years to 80 years. Cases initially treated at an outside hospital and then referred to the teaching hospital were excluded from the study. All deceased cases were excluded from the study. Informed consent was taken from the patient or relatives after explaining to them in the vernacular language. The demographic details, history provided and ocular findings were documented in a prestructured proforma and analysed.

Results

The 48 cases were analysed by gender, age, locality, inflicted eye, mode of injury, type of injury as per Birmingham eye trauma terminology system (BETTS) classification[14] and the associated injuries. There was a preponderance of male patients (64.5%, n=31) over the female patients (35.5%, n=17). 75% (n=36) of cases were from the rural population and 25% (n=12) from the urban population. The common age group affected was 21-30 years in both sexes attributing to 35.48% of males and 29.41% of females as depicted in Table 1. Maximum injuries were inflicted at home (47.91%) followed by injuries suffered on the road (31.25%) as shown in Table 2. Road traffic accidents (29.16%) were the most common mode of accidental injury as tabulated in Table 3. Left eye (58.33%) was more commonly affected compared to the right eye (41.66%). Closed globe injuries were appreciated in 22 cases (45.83%) and open globe injuries in 8 cases (16.66%).In 33.33% of cases (16 cases), mid facial trauma was the most common associated injury.

Figure 1: Case of RTA resulting in grazed abrasion and laceration around the eye

Figure 2: Case of RTA resulting in laceration below the lower eyelid

Figure 3: Blunt force trauma resulting in black eye

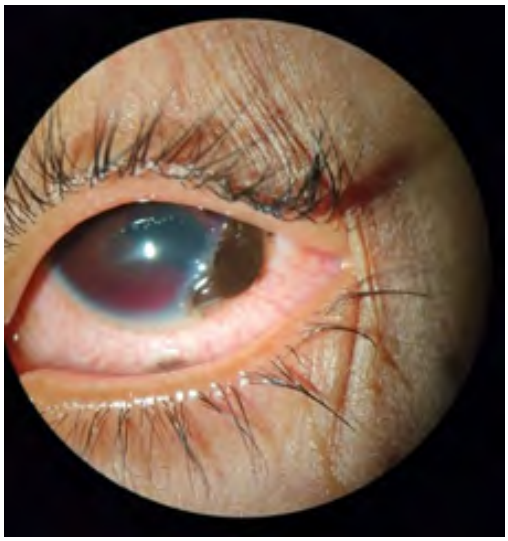

Figure 4: Case of domestic violence (blunt force trauma) resulting in corneal tear with iris prolapse and hyphema

Figure 5: Case of firecracker injury resulting in corneal tear with iris prolapse and hyphema

Figure 6: Postoperative status of firecracker injury (fig 5) resulting in partial visual impairment

Table 1: Age and sex distribution

	Males	Females	Total & percentage
0-10years	03	03	06(12.5%)
10years-20years	04	04	08(16.66%)
21years-30 years	11	05	16(33.3%)
31years-40years	09	01	10(20.8%)
41years-50years	01	00	01(2.08%)
51years-60years	02	01	03(6.25%)
>60years	01	03	04(8.33%)
Total	31	17	48

Table 2: Place of occurrence of injury

Place of injury	Number of cases and percentage
Home	23(47.91%)
School	06(12.5%)
Workplace	02(4.16%)
Road	15(31.25%)
Field	01(2.08%)
Wine store	01(2.08%)

Table 3: Mode of injury

Mode of injury		Number of cases and percentage
Accidental	Road traffic accidents	14(29.16%)
	Workplace	01(2.08%)
	Firecracker	08(16.66%)
	Sports	06(12.5%)
	Self fall	12(25%)
	Needle prick injury	01(2.08%)
	Bull horn injury	01(2.08%)
	Fingernail injury	01(2.08%)
Assault	Blunt weapon	04(8.33%)
	Sharp weapon	00

Table 4: BETTS classification on the type of injury

Type of injury		Number of cases	
Closed globe injury	Contusion	18	22 (45.83%)
	Lamellar laceration	04	
Open globe injury	Penetrating injury	05	08 (16.66%)
	Perforating injury	00	
	Intraocular foreign body	03	

Table 5: Comparison of type of ocular injury with other studies

Study	Closed globe injury	Open globe injury
Tripathy et al[3]	61.70%	15.42%
Yadav et al[14]	24.5%	75.5%
Shashikala et al[6]	94.4%	2.9%
Syal et al[17]	60.5%	26%
Mahdi et al[10]	59.4%	40.6%
Chaikitmongkol et al[7]	42.57%	57.42%
Present study	45.83%	16.66%

Discussion

The current study observed a male dominance of ocular trauma which could be related to accidents following alcohol consumption, occupational exposure, participating in sports and risk taking behaviour. This was consistent with the studies conducted by other authors.[3,14-16]

The present study observed that the common age group affected is youngsters in the age group of 20-30 years. Similar observations were observed in studies conducted by Yadav et al,[14] Shashikala et al,[6] Syal et al[17] and Laishram et al.[15] Studies conducted by Tripathy et al [3]and Puzari et al[5] observed that the common age group affected were in the range 30-40 years.

A large number of cases sustaining ocular trauma belonged to the rural population in the present study, which could be due to illiteracy, ignorance and occupational exposure without adequate preventive measures. However studies conducted by Laishram et al[15] and Movahedinejad et al[16] revealed a majority of cases belonged to the urban population.

The commonest mode of ocular trauma in the present study was road traffic accidents (RTA).The common injuries sustained include abrasions, lacerations and contusions around the eye (Fig 1,2,3). Studies conducted by Tripathy et al[3] and Yadav et al[14] observed assault to be the commonest mode of injury and studies conducted by Laishram et al,[15] Movahedinejad et al[16] and Syal et al[17] observed workplace injury to be the commonest mode of ocular trauma.

Even though road traffic accidents were the commonest mode of accidental injury, it was observed that the commonest place of injury was at home. This could be attributed to a huge number of cases of accidental self fall seen in children and elderly at home, case of domestic violence (blunt force trauma as shown in Fig 4) and trauma sustained due to fireworks (Fig 5&6). Similar findings were appreciated in a study conducted by Al-Mahdi et al[10] on the paediatric age group. The present study revealed two cases of accidental workplace injury; slaked lime induced chemical injury at a construction site and needle prick injury suffered at a nursing home.

The injuries were classified according to the Birmingham eye trauma terminology system (BETTS) into closed and open globe injuries as shown in Table 4. Closed globe injuries (CGI) were further classified into contusion and lamellar laceration; open globe injuries (OGI) were classified into penetrating, perforating and intra ocular foreign body. Closed globe injuries outnumbered open globe injuries in the present study. Table 5 compares the type of injuries to other studies. The findings in the present study are similar to the findings of Tripathy et al,[3] Shashikala et al,[6] Syal et al[17] and Mahdi et al[10] and contrast to the findings of Yadav et al[14] and Chaikitmongkol et al.[7]In the present study, among CGI, contusions(black eye) was commonly seen in cases of road traffic accidents, assault with fist, sports injuries and self fall among the elderly. Among OGI, penetrating injuries were seen in case of needle prick injury, bull horn injury and fingernail injury and intra ocular foreign body was appreciated in firecracker injury.

Out of the 48 cases of ocular trauma studied, only one case resulted in permanent and complete loss of vision of left eye (case of road traffic accident).Permanent and partial loss of vision was seen in 22 cases of ocular trauma.

Forensic aspects

As per the definition prescribed by WHO, a person who is unable to count fingers from a stipulated distance of three metres would be regarded as legally blind.[18] The question of ocular traumas resulting in visual impairment and blindness arise in civil and criminal cases. Among civil cases, commonly seen are cases related to compensation and insurance claims. Among criminal cases are assaults, accidental trauma or a legal proceeding of negligence against a doctor. The opinion of the doctor is needed to establish causation between nature and extent of permanent impairment and injury. It is always important to document injuries and photographs and they serve as key forensic evidence in the Courts of law. The Courts fix the quantum of punishment based on the opinion of the doctor regarding loss of function.

Ocular trauma & Section 320 Indian Penal Code (IPC)

The clauses of grievous injury that are applicable to ocular trauma are defined in Section 320IPC.

Second clause-Permanent privation of sight of either eye

Fifth clause-Destruction or permanent impairment of powers of any member or joint; Eg: Disinsertion/laceration of extra ocular muscles causing restriction of extraocular movements of the eyes.

Sixth clause-Permanent disfiguration of head or face: disfiguration of face due to injury to the lids, orbit, eyeball; residual defects after healing; i.e ptosis, entropion and squint, etc even though vision may be normal

Seventh clause-Fracture or dislocation of bone or tooth: fracture of orbital walls

Eight clause-Any hurt which endangers life or which causes the sufferer to be during the space of twenty days in severe body pain or unable to follow his daily routine

It is to be noted that the doctor should give opinion after complete healing which may take six weeks or six months or more on an average. Hence, follow up assessment to determine whether the disability or disfigurement is permanent or temporary is essential.[1]

Ocular trauma and assault

The present study included cases of drunken brawl and domestic violence resulting in ocular trauma being inflicted by a blunt weapon.

The Protection of Women against Domestic Violence was incorporated in the year 2005 and the punishment for subjecting a woman to cruelty either by the husband or relatives of husband is punishable under Section 498A IPC with an imprisonment upto three years and fine.

Ocular trauma is commonly seen in victims of vitriolage and in one third of the cases they result in complete or partial blindness. To deal with the gravity of such offences, Section 326A and Section 326B was amalgamated in the existing Indian Penal Code from 2013.Section 326A penalises voluntarily causing grievous hurt by use of acid, etc with an imprisonment of not less than ten years but which may extend to imprisonment for life, and with fine. Section 326B penalises an attempt to throw acid with an imprisonment of not less than five years but which may extend to seven years, and with fine. Such victims who have suffered loss or injury shall be paid compensation under Section 357A of Code of Criminal Procedure (CrPC) for the purpose of rehabilitation.[19]

Ocular trauma and occupational hazard

The present study included a case of workplace injury resulting in accidental fall of slaked lime in the eyes. It is estimated that 90% of eye injuries can be prevented through the use of protective eyewear[7].These injuries affect young adults in their productive years with obvious economic consequences. It is the duty of the employer to educate employees regarding possible serious eye injuries at work and provide protective eyewear. Employees may be covered under Employees State Insurance (ESI) scheme or Workman's Compensation (WC) Act. For an organisation to be covered under the ESI scheme, there should be more than twenty employees, and employees who receive an income of less than twenty one thousand rupees per month are deemed eligible. Both the employer and employee contribute equally towards a monthly premium availing health and disability benefits. WC Act applies to an organisation employing any number of workers, including menial job workers whose monthly salary is less than fifteen thousand rupees. The premium is entirely paid by the employer and the employee has access to disability benefits. The compensation awarded is calculated based on the age of the employee and the degree of temporary, partial or complete disability.[20]

Ocular trauma and Road traffic accidents

Throughout the globe, road traffic accidents (RTA) related ocular trauma constitutes 5% to 13% of all ocular traumas.[13]In the present study, the commonest mode of ocular trauma was appreciated in road traffic accidents constituting to almost 30% of the cases and among them 71.4% tested positive for alcohol. A study conducted by Larona et al[4] revealed 73.5% of cases positive for alcohol. Road traffic accidents are usually associated with life threatening head injuries, mid facial trauma and systemic injuries. A study conducted by Yadav et al[14] revealed the presence of associated head injury in 3% of ocular trauma cases. Road traffic accidents usually involve monetary compensation and insurance claims and hence require a meticulous examination and an accurate opinion. Primary preventive approach through safe riding and driving practices and strict implementation of traffic rules like speed monitoring, compulsory helmet and seatbelts, testing for alcohol levels should be enforced.

Ocular trauma and Malingering

Medico legal consultants should not be fooled by victims feigning visual impairment. Feigning may take several forms. The individual could be a deliberate imposter or exaggerating a disability, most commonly intending monetary gains. Malingering of visual loss (bilateral or unilateral) is common and may be discovered by the various tests for malingering. Other patterns of malingering are exaggeration of visual defect as happens in assaults causing corneal opacities. These may be discovered by the disproportion between the visual acuity claimed and the physical signs.[2]

Another pattern of malingering is claiming an old injury caused by an accident or disease to be as a result of a new alleged assault. Scrutiny of the same or other eye may reveal the truth. The opinion should give an indication of the age of injuries, the conclusions drawn from the injuries and whether the findings are consistent with the complaint.

Ocular trauma and medical negligence

In litigations of alleged medical negligence filed under Section 337 & 338 IPC, the onus is on the patient to prove that there existed a doctor patient relationship and that there was a breach in the standard of care and he must connect the negligent act or omission with the damage suffered. For negligence to be proved, the professional behaviour of the doctor must have fallen short of the minimum which the patient is entitled to expect from a doctor of that particular experience, in those

particular circumstances.

Such litigations can be prevented by adhering to the standard or prescribed protocol, taking an informed consent, accurate documentation, adequate follow up, keeping updated with the recent advances and lastly but importantly providing empathy.

Conclusion

The pattern of traumatic ocular injuries reveals that ocular trauma can be considered a preventable health problem. Not only should ocular traumas be considered as a clinical issue, it should also be addressed as a public health issue. It involves targeting groups at risk, public awareness programmes and strict legislation for the use of personal protective devices.

It is important for every doctor, in fact, every health care worker to be familiar with forensic issues involved in ocular trauma. Even though the primary duty is to provide patient care, the medico legal aspects associated with all cases of trauma should be adequately dealt with. The medico legal report forms the basis of evidence in Courts and the opinion should be accurate, complete and unbiased.

Since the study was confined to only a certain region in Karnataka, the authors encourage further studies in different parts of India involving larger populations to know the pattern of traumatic ocular injuries and recommend separate studies on each mode of injury. Though the authors have made a sincere attempt to list all the possible medico legal issues involving ocular trauma there may still be a certain amount of lacunae which can be filled through further studies. To conclude, the study definitely indicates that there is an urgent need to step up safety precautions to prevent disabling eye injuries and sensitises health care workers on the medico legal issues involved.

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ORIGINAL ARTICLE

Effect of first sixty-eight days of lockdown due to COVID-19 on autopsy cases in a tertiary care teaching hospital situated in a rural area of Himachal Pradesh

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Abstract

COVID-19 virus and disease were unknown before the outbreak began in Wuhan, China, and now it is a pandemic affecting many countries globally including India. On 30th of January, 2020 India reported its first case of COVID-19 in Kerala and on 24th of March 2020; the Government of India ordered a nationwide first phase of lockdown for 21 days. Our study is to compare the number and type of cases brought for medico legal autopsies in our institution during the complete lockdown period of first 68 days i.e., 25th of March to 31st of May, 2020 versus the cases brought to the same mortuary during the same period of the years 2018 and 2019. In total, 55 cases (42 were of males and 13 were of females) were brought to the mortuary in this lockdown period constituting 19% of total case of 2020 as compared to 91(21%) cases and 99 cases (21%) in the years 2019 and 2018 respectively. Present study shows drastic fall in motor vehicle accidents and shows increase in natural causes of deaths but the suicidal tendencies in the form of hanging and poisoning remained almost same as compared to previous two years and did not increase.

Keywords

COVID-19; Lockdown; Rural area; Medico-legal autopsy; Accidents; Suicides; Natural deaths

Introduction

COVID-19 is the infectious disease caused by the novel Corona virus also known as COVID-19. This new virus and disease were unknown before the outbreak began in Wuhan, China, in December 2019. COVID-19 is now a pandemic affecting many countries globally including India.[1] On 31st of December 2019, the World Health Organization (WHO) was formally notified about a cluster of cases of pneumonia in Wuhan City. The virus responsible was isolated on 7th of January, 2020 and its genome was separated on 12th of January, 2020. The cause of the severe acute respiratory syndrome that became known as COVID-19 was a novel Corona virus, SARS-CoV-2.2 On 30th of January, 2020 India reported its first case of COVID-19 in Kerala, which increased to three cases by 3rd of February; all were students returning from Wuhan. On 4th March, 22 new cases were reported, including 14 infected members of an Italian tourist group.[3] On 12th March, a 76-year-old man, with a travel history to Saudi Arabia, became the first COVID-19 fatality of India.[4] In view of this, on 24th of March 2020, the Government of India ordered a nationwide lockdown for 21 days, limiting movement of the entire 1.3 billion population of India as a preventive measure against the COVID-19 pandemic in India. [5]

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Slowly and slowly this infection spread to the other states including Himachal Pradesh. The first case was recorded in this region on 20th of March 2020. A 68-year-old man had died in Kangra, Himachal Pradesh after being tested positive for the novel Corona virus Covid-19. He was of Tibetan descent and had travelled from US to Delhi, before reaching Kangra.[6] In Himachal Pradesh, the state Government, on 14th of March, 2020 Himachal Pradesh ordered to closed educational institutions and theatres till 31 March 2020, and also banned entry of foreign and domestic tourists on 19 March till further notice. Later on from March 24, the state Government imposed an indefinite state-wide curfew to combat Corona virus.[7,8] In order to reduce transmission of Covid-19 infection, many hard steps taken by the Government of India including nationwide closing of businesses, travel restrictions, controlled movement of individuals. Main concern was to prevent the transmission of the virus and after effects of infection i.e. to decrease the mortality rate. The lockdown was justified by the government and other agencies for being defensive to prevent covid19 spread and bye some time for preparation of medical tools for battle against said pandemic.

Aim of our study is to compare the number and type of cases brought for medico legal autopsies in our institution during the complete lockdown period of first 68 days i.e., 25th of March to 31st of May, 2020 versus the cases brought to the same during the same period of the years 2018 and 2019. This time period of first sixty-eight days is selected for study as after 31st of May,2020, the process of partial unlocking had started with the Govt. announcing Unlock -1 phase w.e.f. 1st of June, 2020.

Materials and Methods

Our study comprises of all the Medico-Legal cases brought for autopsies to the mortuary of Dr. Rajendra Prasad Govt. Medical College, Kangra situated at Tanda, from 25th of March to 31st of May 2020. Medical history as well as history of incident was obtained through hospital records and police information that accompanied the dead body, as well as through brief interviews with the relatives of the deceased. The data obtained was computed and descriptive analysis of baseline characteristics were analysed and summarized. In all COVID-19 suspected cases by history given by relatives or others, autopsy conducted after test as per autopsy protocol of department. No COVID-19 positive cases were found in our study.

Results

In total, 55 cases (42 were of males and 13 were of females) were brought to the mortuary in this lockdown period from 25th March to 31st May 2020 constituting 19% of total case of 2020 as compared to 91(21%) cases and 99 cases (21%) in the years 2019 and 2018 respectively (Table 1). Present study shows motor vehicle accidents which constitutes 3 cases (5.5%) in this complete lockdown as compared to 15 cases (16.5%) in 2019 and 16 cases (16%) in 2018 (Table 2). Similarly, there is no case of death due to snake bite in this complete lockdown period as compared to 1 case (1%) in 2019 and 2 cases (2%) in 2018 (Table 2). There is also a decrease in the cases of fall which constitute only 4 cases (7%) in complete lockdown period as compared to 10 cases (11%) in 2019 and 8 cases (8%) in 2018 (Table 2).

During the complete lockdown period there were 3 cases (5.5%) due to firearm injuries as compared to only 1 case (1%) in the same period in 2019 and 3 cases (3%) in 2018 (Table 2). In our study 14 cases (25.5%) of natural deaths were brought for medico legal autopsy due to some suspicion regarding cause of death as compared to 8 cases (9%) in 2019 and 7 cases (7%) in 2018 (Table 2). The number of hanging and poisoning cases constituted 17 (31 %) as compared to 30 cases (31%) and 33 cases (33.33%) in the years 2019 and 2018 respectively (Table 2).

Table 1: Comparison of number of cases in first sixty eight days of lockdown with total number of in year 2020 (COVID phase) with consecutive previous two years i.e. 2019 and 2018 of pre- COVID Phase

Year	Total cases in a year	Number of cases of first 68 days of year
2018	477	99
2019	423	91
2020	394	55

Table 1: Distribution of cases according to cause of death in first sixty-eight days of lockdown in 2020 in comparison to previous two years i.e., 2019 and 2018 of pre- COVID phase

Cause of death	2018	2019	2020
Poisoning	29	14	11
Motor vehicle accident	16	15	3
Fall	8	10	4
Burns	16	7	5
Electrocution	1	1	0
Assault by blunt weapon	4	2	1
Assault by sharp edged weapon	1	0	0
Mechanical Asphyxia	1	0	0
Firearm injuries (Homicidal)	3	1	0
Firearm Injuries (Accidental/Suicidal)	0	0	3
Accidental strangulation	0	0	1
Snake bite	2	1	0
Insect bite	0	1	0
Hanging	4	17	6
Drowning	3	9	3
Alcohol intoxication	1	2	0
Natural deaths	7	8	14
Cause of death: inconclusive	3	3	4
Total	99	91	55

Discussion

There is only 2% decrease in the number of medico legal autopsies during COVID-19 complete lockdown period which constitutes about 19% of total cases as compared to 21% in the years 2018 and 2019. Decrease in the number of cases by 2% is mainly due to decrease in the number of accidental deaths. All types of accidents have decreased during this period i.e., road side accidents, accidents due to fall, snake bites etc. probably due to the reason that the people were less mobile due to various restrictions during this period in the form of lock down and curfew. Our study also showed that there is a drastic fall in motor vehicle accidents about 1/3rd, the reasons being the number of vehicles on the roads was less and even the pedestal movement of people was restricted. This study also showed that there is an increase in the firearm injuries as compared to previous two years.

The data also shows that there is an increase in natural causes of deaths in this complete lockdown period as compared to previous two consecutive years which could be due to the reason that the people were living a sedentary lifestyle due to closure of their business establishments and work from home

culture in private sector. The other reason being that the whole focus was on COVID-19 and the people avoided going to hospitals for the regular check-up of their chronic ailments like Cardiac diseases, Chemotherapy /Radiotherapy for Cancer patients etc. Private sector medical facilities i.e., nursing homes, private clinics and hospitals etc. could not provide the medical facilities to the people to their full capacity due to various unavoidable and unexpected circumstances resulting in the complete dependency of people on the Govt. sector hospitals which were already overburdened with the patients of COVID-19 but still managed to provide quality health care services to the masses.

On the other hand, as most of the newspaper reports showed that there was increased trend of suicide in the form of hanging and poisoning during this lock down period.[9] But our study did not support this as the suicidal tendencies in the form of hanging and poisoning remained almost same as compared to previous two years and did not increase may be due to the reason that people were mentally prepared to fight this pandemic. However, gunshot cases show increasing pattern. The financial constraints were there but were dealt with courage to some extent due to the peculiar habit of savings in Indian community and family values of supporting each other still exiting in our country.

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ORIGINAL ARTICLE

Detection of sutural diastasis in traumatic head injury: A diagnostic dilemma

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Abstract
Following head trauma, diastasis of the cranial sutures may occur with or without skull fractures and may be the only indication of skull damage. Axial non-contrast CT scanning is the gold standard technique for evaluating head injury. However, detection of sutural diastasis may not be possible at normal axial views of CT scan, which can lead to dilemma in medico-legal cases. Therefore, the present study was aimed to detect the sutural diastasis in cases of traumatic head injury brought for medico-legal postmortem examination and comparing them with antemortem radiological evaluations. The cases of traumatic head injury that underwent medico-legal postmortem examination during the two years were studied retrospectively. The cranial sutural separation observed in the study subjects during autopsy was compared with the antemortem radiological investigations, which were collected from the hospital records of the deceased. Sutural separation was detected in 5 out of 60 cases that died due to head trauma. All sutural diastasis were extensions of linear/ depressed or comminuted skull fracture. None of the NCCT head report sutural separation, while associated fractures were diagnosed. Medico-legal significance of sutural diastasis is akin to skull fracture. Detection of sutural diastasis may not be possible at normal axial views of CT scan, which are routinely performed in trauma settings. Thin slices on axial plane during CT scan with sagittal and coronal reformations can better delineate sutural diastasis. To minimize the risk of misdiagnosis, a cautious approach in radiological diagnosis of sutural diastasis is desirable, especially in medico-legal cases.

Keywords
Head injury; Suture; Diastasis; CT scan; Autopsy; Fracture

Introduction

The human skull is bony cage that forms the cavity for brain. The vault of skull is comprised of seven bones; the paired frontal, temporal, and parietal bones, and the single occipital bone which are associated together by sutures.[1,2] Sutures are fibrous joint that occurs only in the skull. The paired coronal, lambdoid, temporal sutures, the single sagittal and metopic sutures are the prominent sutures of vault of skull.[1,2] Cranial sutures are imperative for cranial vault growth and consequently, brain growth, as further expansion of the braincase is unlikely once they fully ossify.[3] These sutures ossify with advancing age. Metopic suture is first to obliterate, at around 9-24 months of age. While rest of the sutures obliterates at around 30 years of age.[4,5] Abnormal splaying of these sutures signifies sutural diastasis. Sutural diastasis could be seen due to the multifactorial causes such as intracranial tumour, hydrocephalus, other structural, systemic and infectious causes, especially in new born babies and infants or it can be a sequela to head trauma.[3] Following head trauma, diastasis of the cranial sutures may occur with or without skull fractures and may be the only indication of skull damage. As long as a suture is visible radiologically, the likelihood of its separation by trauma must be endured.[6,7] Sutural widening is generally symmetrical when occurring secondary to raised intracranial pressure and the traumatic diastasis of suture is often irregular and asymmetrical.[7]It can occur in young without substantial force, but in the adult patient with fused sutures, it is an emblem of significant trauma and may well be accompanied with intracranial complications.

Radiologic examination such as skull radiographs and computed tomography (CT) scan of the head is fundamental in patients suffering from head trauma. CT scan examination is considered indispensable imaging technique for diagnosing and management of patients in the acute stage of closed head injuries. Axial non-contrast CT scanning is the gold standard technique for evaluating head injury.[8] However, detection of sutural diastasis may not be possible at normal axial views of CT scan.[9] In all medico-legal injury cases, reliance is placed on the radiological investigations for inferring the nature of injury. On numerous occasions, CT scan is considered to be the final authority for opining the nature of injury, particularly in cases of head injury. Many a times, conflicts arise when nothing is evident even on CT scan despite local and clinical findings. Studies are needed to know the precision and accuracy of radiological investigations; this can be achieved only by comparing the same with postmortem revaluations. Therefore, the present study was aimed to detect the sutural diastasis in cases of traumatic head injury brought for medico-legal postmortem examination and comparing them with antemortem radiological evaluations.

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Material and Methods

A retrospective study was undertaken at a tertiary care center of northern India where the cases of traumatic head injury that underwent medico-legal postmortem examination during the period of two years were studied. Only those cases, which underwent radiological evaluations of the head prior to death and didn't undergo any sort of surgical intervention, were selected for the study. The cranial sutural separation observed in the study subjects during autopsy was noted down and compared with the antemortem radiological evaluations (X-ray skull and NCCT head), which were collected from the hospital records of the deceased retrospectively. The CT scans were carried out on a spiral CT scanner (SIEMENS make SOMATOM with volume zoom +4). In the CT scan, 5mm contiguous slices were acquired at an angle of 15–20 degrees to the cantho-meatal line from the base of skull to the vertex in the axial plane. To authenticate the findings documented in CT reports and to remove the observer bias, if any, senior radiologist again reviewed CT scan films.

Results

Total of sixty cases of head injury underwent medico-legal postmortem examination during the period studied. Sutural separation was detected in 5out of 60 craniums. Out of 5 cases, one deceased was of 6 years of age, 3 were of 21-25 years and one of 80-year-old. Three had died due to road traffic accident, one railway accident. While the old age deceased had blunt trauma head as causative agent of head injury.

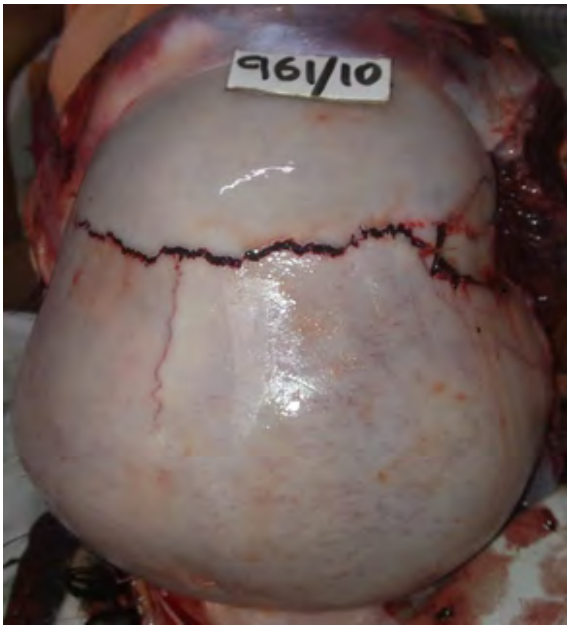

Figure 1: Depressed fracture over right frontal region with coronal suture diastasis

Figure 2: Comminuted fracture of right frontal region with coronal suture diastasis

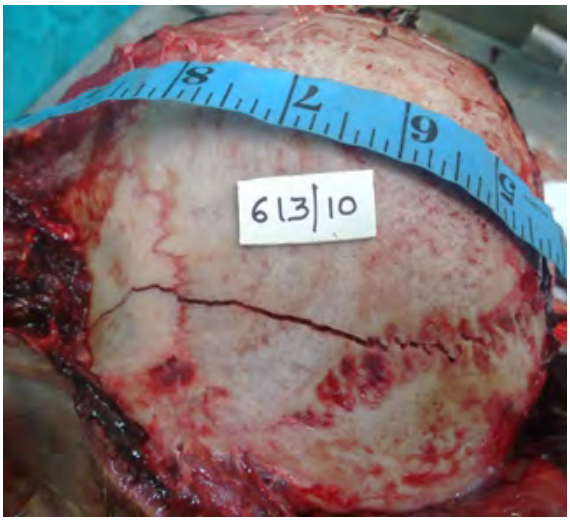

Figure 3: Linear fracture over left temporo-parietal region extending to lambdoid suture causing its diastasis

Coronal suture separation was seen in three cases, one had lambdoid suture separation while temporal suture separation was seen in one case. No isolated sutural separation was observed. All sutural diastasis was extensions of linear/ depressed or comminuted skull fracture. Sutural diastasis was not reported in any of the NCCT head done during antemortem period, while associated fractures were diagnosed. Out of the 5 cases, that reported sutural diastasis, 4 had skull X-rays during antemortem period and only fracture was reported in them.

Discussion

Development of cranium through sutures continues until 12 years of age.[10] At birth, the cranial sutures measure up to 1 cm, which narrowed significantly by the age of three years when width reduces to 2 mm.[11,12] Sutures starts obliterating in second decade and the ossification of cranial sutures continues until the fourth decade, after which they obliterates.[10] In normal course, various cranial sutures are relatively uniform in diameter and have "zigzag" or interdigitating pattern with sclerotic borders. They tend to join other sutures rather than crossing them.[13] Sutural diastasis can be traumatic or pathological.[3] Widening of sutures due to raised intracranial pressure is commonly seen in children, but it is rare in adults. Head trauma can lead to sutural diastasis when the fractures occur along the line of a suture.[12,14] In children and young adults, a linear fracture may pass into a suture line and cause a diastasis or opening of the weaker seam between the bones.[15] In our study, we have observed that majority (3/5) of sutural separations were seen in young adults. Only one sutural diastasis was observed in child, which was of 6 years of age. Diastasis in an 80-year-old deceased due to head trauma was also observed in our study. All sutural diastasis was extensions of linear/ depressed or comminuted skull fracture. No isolated sutural diastasis was observed. However, cranial suture diastasis may occur in absence of skull fractures and may be the only indication of a head trauma.[16]

Radiological examination is routinely performed in evaluation of trauma cases in emergency settings. CT scan is the preferred modality of investigation trauma centers in head injury cases. CT scan has replaced conventional skull radiographs in head trauma investigation. Detection of fracture skull during CT examination alarms the clinicians as well as radiologists. Fracture skull bone is an indicator of substantial assault to the head, with possible injury to the vital contents. Rather than the fracture itself being a danger to life, intracranial damages associated with fracture can have grave consequences. There are occasions, when the crack passes through an embedded meningeal artery causing a meningeal haemorrhage, which is considered later.[15] The dilemma for radiologist's lies is deciding whether a translucent line seen on X-ray and CT films, is a fracture or a suture or vascular marking.[12,17] This differentiation is even more challenging in the pediatric population, where numerous sutures have a variable appearances.[17] In a reported case by Wiedjik et al., post-mortem radiography of skull depicts a linear fracture of the parietal bone. In contrary, autopsy indicated no signs of mechanical trauma. Instead the linear fracture demarcated was as a unilateral accessory suture of the parietal bone.[18] Tharp & Jason also observed in a case where anomalous parietal suture was misdiagnosed as parietal skull fracture by ante-mortem CT scan, which was contradicted at autopsy by postmortem histologic examination.[19] The distinction between normal sutural anatomy and fractures is critical, as it signal the radiologist to impending intracranial injury.[20] Unfortunately, there is a relative scarcity of literature specifying the appearance of normal suture anatomy at CT.[13] Some fundamental rules can be applied to help differentiate sutures from fractures. Fractures have sharp, no sclerotic borders and may bifurcate. They may cause diastasis of the sutures, often cross the sutures themselves, and increase in diameter as they approach a suture. Incidental findings such as overlying soft-tissue injuries, including hematomas, can be worthwhile in differentiating fracture from normal sutural appearance.[17] While sutures are relatively uniform and have "zigzag" or interdigitating pattern with sclerotic borders.[13]

It was observed in our study that the extension of fractures had reached up to the sutures which were found separated in five victims of head injury whose CT scan have reported the fractures and no remarks on suture separations. Detection of sutural diastasis may not be possible at normal axial views of CT scan.[9] In our study, 5mm contiguous slices were acquired at an angle of 15–20 degrees to the cantho-meatal line from the base of skull to the vertex in the axial plane during CT imaging. However, one-millimeter-thick images reconstructed at 0.8–1-mm intervals by using a bone or "sharp" (high-frequency) algorithm are recommended for axial and multiplanar imaging for evaluation of sutural diastasis during CT imaging.[13] It can be challenging to appreciate fine sutures and fractures in a single plane; thus, thin-section volumetric acquisition is preferable to sequential "step-and-shoot" acquisition. Standard sagittal and coronal reformatted datasets in the orthogonal plane improve interpretation of thin-section axial images. Three-dimensional (3D) shaded-surface volume-rendered CT images are also valuable in swiftly delivering an impression of the sutures, their course, separation, and symmetry, all of which are handy in discriminating sutures from fractures.[21] Even with the invent of multiplanar, three-dimensional imaging, images are still interpreted in the axial plane only on a CT scan of the head in developing countries, which may be due to lack of financial and human resources.[22] No sagittal and coronal reformations of axial images were done in our study and also the slice thickness was 5 mm, which is much more than the recommended 0.8-1 mm thickness contiguous slice.

There is no substance lies in the fact that in our study fracture was diagnosed but sutural separation was missed, as it didn't alter the cause of death. However, isolated sutural diastasis in not an unknown entity.[16] An undisplaced fracture or sutural diastasis without any intracranial abnormality may be insignificant for clinicians from treatment point of view, but medico-legally it has relevance. The nature of injury, whether it is simple or grievous, depends upon the radiological reports in living. Molina et al. concluded that the CT scans may be acceptable for clinicians in the emergency room setting, but are inadequate for courtroom testimony. Since they have a low

level of accuracy in detecting traumatic injuries, CT scans are an inadequate diagnostic tool for forensic pathologists, where a decisive diagnosis is required. There is a likelihood of erroneous indictments and convictions, if the evidence of trauma is based solely on CT scan reports.[23] Demonstration of diastasis of a skull suture should have the same medico-legal significance as the demonstration of fracture lines.

Conclusion

Sutural diastasis due to trauma is not a rarity in head trauma cases. It may occur in absence of skull fractures and may be the sole indication of a head trauma. Medico-legal significance of sutural diastasis is akin to skull fracture. Detection of sutural diastasis may not be possible at normal axial views of CT scan, which are routinely performed in trauma settings. Thin slices on axial plane during CT scan with sagittal and coronal reformations can better delineate sutural diastasis. To minimize the risk of misdiagnosis, a cautious approach in radiological diagnosis of sutural diastasis is desirable, especially in medico-legal cases.

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ORIGINAL ARTICLE

Estimation of post-mortem interval from vitreous potassium: An autopsy based study

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Abstract

Time since death which is the interval between death and the time of post-mortem examination is important during investigation of a crime. It is also called as 'post-mortem interval' (PMI). A repeated problem in Forensic Medicine is the inability to fix the time when death occurred within the limits of probability. It is self-evident that more the duration between death and the examination of the body, longer will be the limits of probability. In this study, time since death was determined from potassium level in the vitreous humor and a formula was derived for the Chennai region. A prospective interventional study was conducted taking 75 vitreous samples. Potassium estimation was done using a fully automated analyzer- Siemens ADVIA1800. During the studied post-mortem period, a consistent liner rise of vitreous potassium was seen. The mean range of vitreous potassium concentration in the subjects varied between 5.4 mmol/L to 36.00 mmol/L (Mean ± SD, 19.30 ± 6.64). In the present study the average rate of increase of vitreous potassium was calculated as 0.931 mmol/L per hours with 95% confidence limit over ± 20 hours. The potassium-based formula derived from the present study to estimate PMI is: PMI = 1.075 (K+ mmol/L) – 2.53. The coefficient of correlation between post-mortem interval and potassium concentration was found to be 0.997 in the present study, in comparison with studies done by Sturner & Gantner(1963). Vitreous potassium level linearly increase with time since death and can be used as a reliable parameter.

Keywords

Vitreous humor; Potassium; post-mortem interval

Introduction

In every human being death is inevitable, although its occurrence is unpredictable. Thorough investigation of the time of death on the basis of post mortem findings is an important aspect of Forensic Medicine. Apart from its obvious legal importance, its solution has been so elusive as to provide a constant intellectual challenge to workers in many sciences. In spite of the great effort and ingenuity expended, the results have been meagre.[1] The time of death, which is the interval between death and the time of post-mortem examination, is sometimes extremely important. It is a question almost invariably asked by police officers, sometimes with a touching faith in the accuracy of the estimate. 'It is self-evident that more the duration between death and the examination of the body, longer will be the limits of probability.

Thanato-chemistry is the chemistry of death. It is used to describe the changes that occur in the chemical composition of the human corpse as soon as death occurs. In the latter half of the 19th century onwards, PMI was determined using chemical tests such as by measuring the electrolyte concentration of various body fluids like CSF, blood, pericardial fluid, synovial fluid, and vitreous humor. After death, the blood is a poor choice for such analyses due to the rapid breakdown of cell membranes and autolysis that occurs in serum. Of all these body fluids vitreous humor is the only fluid which is unique and preferred. More importantly it has been found that for many substances, the chemical changes occur much more slowly in the vitreous humor when compared to that occurring in the cerebrospinal or fluid blood. Amidst the various methods available most widely sought-after method to estimate the PMI is estimation of vitreous humor potassium concentration.[2] The available literature on biochemical (enzymal) changes in post-mortem blood (serum) and its relation with time since death is largely contributed by forensic scientists from the temperate countries. There had been considerable differences in the various studies conducted because of changes in the climate of geographical distribution, techniques and instruments used for estimating the potassium levels in vitreous humor. Most of the Indian studies were done with flame photometry or semi analysers, which give erroneous results because of manual mistakes. The research gap identified was the use of conventional methods of vitreous potassium level and its reliability in estimating time since death. Though time since death using vitreous humor is well known, most of the studies were done using old methods. The estimation of time since death from vitreous potassium by a fully automated analyser can give valid and reliable data. A precise formula can be made for the study region which will be of use in large for the society in future which is the aim of the study.

This study is done entirely using fully automated analyser,

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which will negate the manual errors and can arrive at a precise formula for calculating the Time since death. Thus, this study serves the society of Chennai & neighbouring areas at large, by deriving a formula to estimate time since death (TSD) from vitreous humor biochemistry which would be of great help for the forensic experts as well as the law enforcing authorities and also to aid judiciary, in solving many queries regarding the time of death and crime.

Material and Methods

The cross-sectional study was conducted in the Department of Forensic Medicine & Toxicology and the Department of Biochemistry from April 2013 to October 2014. All deaths with known time since death, brought to the mortuary for autopsy were included in this study. The cases included both hospital and non-hospital deaths. The cases with known or suspected ocular diseases, cases of trauma where vitreous was contaminated with blood and decomposed or putrefied bodies were excluded from the study. Also, cases in which time of death mentioned in the hospital sheet, inquest report and history of relatives was differing by more than ±30 min, were not included in the study. A written informed consent was obtained from the legal heir or guardian of the deceased. The history was obtained from the legal heir or guardian and filled in the proforma, along with cross verification of data from police inquest and hospital records. The time of shifting to cold chamber and time of autopsy was also noted.

A total of 75 cases were studied, where samples were taken from right eye and analyzed for the biochemistry of vitreous. The samples were collected using 10 ml syringe and number 20-gauge needle. The needle was introduced to the eye through the outer canthus, 4.5 cms lateral to limbus and 1 to 2ml of vitreous humor aspirated as gradually as possible. The eyeball was refilled with saline to avoid sinking. The sample was centrifuged for 3 minutes at 4200 revolutions per minute after heating at 99.6°C in water bath for 3 min. The supernatant was used for estimation of potassium, which was done using a fully automated analyzer- Siemens ADVIA1800**.** The electrolytes were analyzed using ion selective method. The biochemical values of vitreous potassium were noted down. Data were analyzed using computer software, Statistical Package for Social Sciences (SPSS) version 11.5. Appropriate statistical tests were used for deriving the regression formula.

Results

Out of the 75 cases taken for the study, 55 were males (73.33%) and 20 were females (26.66%) indicating a male: female ratio of 3:1in the study. The mean age of the subjects for this study was 40.27 years with SD 17.91. The minimum age for this study was 3 years and maximum was 80 years, with maximum of 38 subjects belonging to the age group of 21 to 40 years and least of 7 subjects between 1 to 20 years (Table 1). The duration between time of death and the time of autopsy was observed and 47 cases (62.66%) were subjected to autopsy within a span of 12 to 24 hours after death. Only 14 (18.66%) cases were taken to autopsy within 12 hours and another 14 cases (18.66%) were taken for autopsy more than 24 hours after death (Table 2). The minimum and maximum value of known PMI in this study was estimated to be 4 hours 50 minutes and 36 hours 40 minutes with an average value of 18.22 hours.

Figure 1 is showing the regression plot of potassium concentration of vitreous humour plotted against the post-mortem intervals in hours. The mean range of vitreous potassium concentration in the subjects varied between 5.4 mmol/L to 36.00 mmol/L (Mean ± SD, 19.30 ± 6.64). The linear regression correlation of vitreous potassium and PMI was found to be highly significant (n, 75; R, 0.997; $P< 0.0001$).

The vitreous potassium concentrations were used as the dependent variable to calculate the estimated PMI. The resulting linear regression equation in the form of

$y = ax + b$

Where,

'y' is vitreous potassium concentration;

'x' is actual PMI in hours;

'a' is the slope of regression line and a = 0.928,

'b' is the intercept of the regression (Y-intercept when X=0.0) and b = 2.397

Thus, the resulting linear regression equation is

$y = 0.928x + 2.397$

$x = (y – 2.397)/ 0.928$ or

$x = 1.075y – 2.53$

Thus, PMI estimated by resulting linear regression formula: $PMI = 1.075(K^{+}) – 2.53$

95% confidence limit of x = Mean ± 2SD of x

= Mean ± 2 x 7.14

= Mean ± 14.28

$$\text{Regression coefficient} = r \frac{\text{SD of x}}{\text{SD of y}}$$

$$= 0.999\ (7.14/6.64)$$

$$= 1.074$$

This indicates that for every 1mmol/L increase of potassium values there could be an increase of 1.074 hrs in the post-mortem interval and at 95% confidence limit for all cases will

be ± 14.28 hrs. Hence the average rate of increase of potassium levels in the vitreous was calculated to be 0.931 mmol/L per hour.

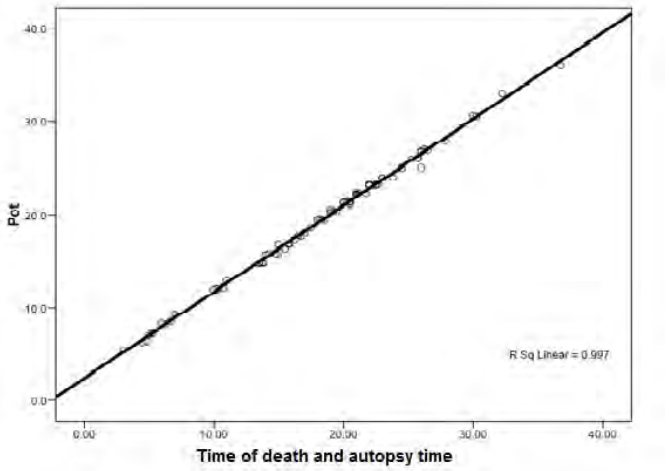

Figure 1: Vitreous potassium level plotted against PMI

Table 1: Distribution of age

Age in years	Number of cases	(%)
1 to 20	7	9.33
21 to 40	38	50.66
40 to 60	17	22.66
60 to 80	13	17.33

Table 2: Time of autopsy after death

Time in hours	Number of cases	(%)
< 12	14	18.66
12-24	47	62.66
>24	14	18.66

Discussion

During the course of an investigation of death, the onus is on the consulting pathologist to accurately estimate the time of death of the deceased individual. One of the vital requirements in medico legal autopsies is to estimate the time since death. In the last few decades various chemical tests have been developed to determine the post-mortem interval. Whole blood, serum, aqueous humour, vitreous humour and cerebrospinal fluid are some of the body fluids that are available for the chemical examination are. Vitreous humor is a fairly stable fluid in the post-mortem period that can be utilized in death time estimations. In this study the vitreous humour potassium concentration is investigated, which is the most widely used method amidst the various methods available. 75 cases were taken for the study, 55 were males (73.33%) and 20 were females (26.66%) indicating a male: female ratio of 3:1 in the study. Amith Mulla et al. (2005) conducted studies with 61 cases with male: female ratio of 3:1.[3]

The mean age of the subjects for this study was 40.27 years with SD 17.91. The minimum age for this study was 3 years and maximum was 80 years, with maximum of 38 subjects belonging to the age group of 21 to 40 years and least of 7 subjects between 1 to 20 years. This was in accordance with a similar study done by Sparks et al (1989) where the range of age varied from 1 to 84 years.[4]

The vitreous humor was collected in room temperature in majority of the cases. After the ages of 45 to 50 years, there is a significant decrease in the gel volume and concomitant increase in the liquid volume of human vitreous. Post-mortem studies of dissected vitreous qualitatively confirmed these findings and determined that liquefaction begins in the central vitreous.[5] In the present study, observations were made up to 37 hours (Mean ± SD, 18.2 ± 7.14) post-mortem period. During the studied post-mortem period, vitreous potassium represented a fairly linear rise with increasing PMI. This linear rise of vitreous potassium was consistent throughout the entire study. These results are in accordance with previous reports in literature on the behaviour of vitreous potassium in the post-mortem period (Sturner and Gantner[6], Coe and Apple[2], Madea et al.[7]) This observation is authenticated by many workers including Jaffe[1], Coe[2], Lie[8], etc. which is a result of the autolysis of the retinal cells and vascular choroids of the eye. This is due to the fact that these cells when they undergo autolysis release potassium into the vitreous humour causing an increase in the potassium levels.

Various technologies have been used to detect vitreous potassium ions. Bortolotti et al.[9] used capillary ion analysis combining UV detection, but had its own issues of lack of sensitivity and complex infrastructure. Zhou et al.[10] measured vitreous potassium by low pressure ion chromatography, but could not delineate the qualitative intervention of other components. Passos et al.[11] reported a sequential injection system for detecting concentrations of K+ ions and hypoxanthine automatically, but had to face complex pre-treatments and long-running operations.

The mean range of vitreous potassium concentration in the subjects varied between 5.4 mmol/L to 36.00 mmol/L (Mean ± SD, 19.30 ± 6.64). In the present study 0.931 mmol/L per hours with 95% confidence limit over ± 20 hours was the average rate of increase of vitreous potassium that was calculated. The slopes of the linear regression line for post-mortem vitreous

potassium rise against PMI reported in literature are variable and in the range of 0.14 mmol/L per hour (Sturner and Gantner) [6] to 0.332 mmol/L per hour (Coe and Apple)[2]. Dalbir Sing et al.[12] in a study done by him found that 0.29 mEq/ hr, was the mean rate of increase of potassium concentration. In a study by Prasad et al[13], he found that the mean rate of increase of vitreous potassium was around 0.21 mEq/L.[10]

The coefficient of correlation between post-mortem interval and potassium concentration was found to be 0.997 in the present study, in comparison with studies done by Sturner & Gantner[6] it was 0.987 and that with Agrawal et al.[14] was 0.985. The average rate of increase of potassium concentration per hour was found to be 0.93 mEq/L, compared to work done by Adjutantis & Coutselinis[15] which was 0.73 mEq/L. Therefore from the data obtained in the current study the potassium-based formula derived to estimate PMI is: $PMI = 1.075 (K^{+} mmol/L) – 2.53$

A highly significant correlation ($P< 0.0001$) was noted when the actual PMI were compared with the estimated PMI using the derived formula. When the potassium data obtained in the present study was substituted in the potassium-based formula, *PMI = 7.14 (Potassium) – 39.1*, previously reported by Sturner[6], the estimated PMI was significantly correlated ($P< 0.0001$) with the actual PMI. Since Chennai region is geographically experiences a tropical and coastal climate, the temperature is hot or warm with high humidity throughout the year. Farmer et al. observed that in warm seasons with higher environmental temperature at the time of death, caused marked enhancement of the observed potassium values in the vitreous humor. It is important to note that all the 75 cases studied were stored in cold chamber before the autopsy. The duration between the time of death to the shifting of body to cold chamber was observed and the maximum number of cases, that is 58 cases were shifted to cold chamber within a span of 1 hour to 2 hours. This shows that in all cases the temperature and humidity factors were consistently maintained after death. Unlike most of the earlier studies, in our study, the analysis of vitreous was done meticulously by a fully automated analyser. This would have added the strong correlation of vitreous humor potassium rise with time since death.

Conclusion

Vitreous potassium level linearly increases with time since death and can be used as a reliable parameter

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REVIEW ARTICLE

Virtual Autopsy – Way forward in Forensic Medicine

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Abstract

Technological advancements in medical sciences have also touched forensic sciences. The procedure of Autopsy still employs traditional approach. An autopsy is a highly specialized surgical procedure consisting of a thorough evaluation of a corpse to determine the cause and manner of death and to pinpoint any disease or injury that may be present. Conventional autopsies are time consuming and quite relentless. So, in 20th century Dr Richard Dirnhofer introduced the term virtual autopsy. Virtual autopsy envisages high tech radiological imaging evidences in cadaveric evaluation. This imaging technique provides an efficient and accurate view on individual case.

Keywords

Autopsy; 3D Imaging; CT scan; Forensic odontology; Virtopsy

Introduction

Death is inevitable to human beings, either natural or unnatural. In case of natural death, time heals the pain associated with human loss and overtime, the kith and kin of deceased accept it. Contrarily, death of unnatural occurrence is invoked for justice from loved ones. It is in this situation that medicolegal or forensic autopsy emerges for establishing the cause of death. "Medico legal autopsy" which is synonymous with "medico-legal necropsy" is the regarded as significant forensic expertise, and hence referred to as "the expertise of expertises".[1]The term "Autopsy" is derived from the Greek work which is a combination of "autos" and "pisa" which means "own" and "view" respectively.[2]

Traditional autopsy procedure results in body mutilation to figure out the cause. This technique has raised serious objections by the relatives of victims. Emotional issues forms the principal objection for autopsy acceptance, but the need for identifying cause of death or identifying an unknown person overrules this aspect. The time required for conducting the procedure is also long, sometimes requiring days. Religious beliefs and cultural taboos further constraints autopsy procedures, especially in religions such as Judaism, Islam and Buddhism where autopsy is not permitted.[3] Subjective judgement is another aspect to not be overlooked. According to Lancet the long-standing public objection to dissection of cadavers reemerged in UK as a major issue after organ retention scandal in the late 1990s.

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Emergence of alternative

Due to the objections raised to traditional autopsy and to further reinforce the results obtained, an alternative approach emerged in the form of radiological imaging, which is applied in forensic science since 1896.[4]The foundation for application of radiological imaging was laid by Martin and Arrorio in 1896 with the observation of cranial sinuses. This new technique was termed as "virtoscopy" or "virtual autopsy" done by employing radiological techniques such as CT, MRI and 3D imaging. Literature also shows cases reporting probable death causes when investigated for injuries in liver, heart, brain and bone.[5,6]

Historical aspect

Virtual autopsy was developed by Richard Dirnhofer, conducting a scalpel free autopsy procedure by employing a combination of 3D body surface imaging technique along with merged CT / MRI and 3D shape analysis. It has a wide application in identification of individuals affected in natural calamities, accidents, homicides, under age deaths and in recognizing foreign bodies like bullet or implants.[7]Foundation for digital autopsy was laid by the creation of "Virtual Mummy" in the British Museum in 2004. Its expansion to dentistry was by Oesterhelweg et al.[8]

Objectives of virtual autopsy

1. To determine cause of severe tissue and bone damage: Virtual autopsy can determine the precise cause and severity of damage. This finding is upheld by the study of Bruck et al[9], in which a pedestrian was involved in traffic accident. Injuries of two types were found – the first was that of vehicle impact and the second was friction of victim with asphalt. With the help of magnetic resonance, both primary and secondary injuries were precisely drawn.

2. To identify injuries and reconstruct in 3D – 3D facial construction is obtained in situations of mass disasters, thanatological evaluation, identification of carbonized and putrefied body, for age and anthropological estimation.
3. Identify the bullet track inside the body – Bullet track injuries are difficult to assess either because of their absence in the human body or diversion into anatomical structures or body parts. Virtopsy helps in identifying projectile location precisely thus facilitating further examinations.[10]
4. Gender identification in severely mutilated bodies- Traditional methods of autopsy had difficulties in age estimation. This imaging technique helps in age and gender estimation of mutilated bodies. Infact, identification of Australian Bushfire victims was based on age estimation method.
5. Identify retained objects in the body – Literature evidence shows Virtopsy detected foreign body located in respiratory tract in a victim. This imaging technique provided an accurate depth of foreign body embedded, with a combination of computed tomography and magnetic resonance imaging.[11]
6. For educational and research purposes – In order to better understand and conceptualize the learning process, virtopsy can be used in academic and research institutions.

Imaging Techniques in virtual autopsy

In the beginning, researchers used only CT and MRI for virtopsy. In the recent times, advanced imaging methods such as angiography, photogrammetry, multidetector CT and MRI, high resolution micro MRI and CT, magnetic resonance spectroscopy and image guided percutaneous biopsy are also employed.[12] An overview of the imaging techniques used in virtual autopsy is presented in the following sections;

- Computed Tomography (CT): The commonly employed clinico – radiological aid in virtual autopsy, providing an ample data of antemortem studies in cases of unknown identification. Landmarks such as paranasal sinuses, implants, pacemakers and bone plates are easily identifiable which is further used for antemortem comparison. They offer the benefit of speed, reliability and lesser cost when compared to other identification methods such as DNA analysis.[13]
- Post mortem computed Tomography: This imaging technique enables visualization of the entire cardiovascular system. In case of any injury to a blood vessel, dye spills into the adjacent tissues which can be seen in the CT images.[14]
- Magnetic Resonance Imaging: It is employed as an important adjunct to CT, enabling visualization of soft tissue organs along with its capability to view bony lesions. Anatomical details are well depicted in Postmortem setting due to the absence of motion artifacts.[15]
- Post mortem Computed Tomography Angiography: The entire cardiovascular system can be visualized employing PM angiography. If a vessel has some damage, there will be spillage of dye into the underlying tissue to make it noticeable.
- Post mortem biopsy: A biopsy gun is used in technique to procure samples from targeted organs such as the heart or any specific lesions observed in CT or MRI. Recently, image guided sampling with a dedicated robot is introduced.
- 3D photogrammetry based optical surface scanning: This technique projects a 3 D image in a fringe pattern using a surface scanning unit with the help of a specialized software. Real life 3D surface reconstructions are made by addition of photographs taken from different angles. This imaging provides an accurate documentation of structures which are lesser than 1 mm in size as well[16]. This technique merges color surface scan with gray scale radiographs which offers the advantage of being objective, non – invasive and storable for a longer duration.
- Magnetic resonance microscopy: Study of soft tissue injuries are done like electric injury to skin, retinal haemorrhage. With this technique we can also study pattern of injury and weapon involved.
- MDCT: Multi detector computed tomography identify haemorrage, air, pneumothorax, nerve lesions, vessel injuries.
- Virtobot System: The Virtobot is a 6 axis industrial robot, which is mounted on external orbit of the CT couch, such that the total scannable volume can be accessed. The end effector can be changed and multiple tools can be mounted. The system envisages a navigation device to allow for a closed loop robot control. At present, techniques of automated surface scanning and minimally invasive biopsy exist[17].

Merits of virtual autopsy-

1. It is noninvasive technique enabling visualization of interested region with great accuracy. It can be even less invasive when one opts for percutaneous biopsies.
2. Time needed to complete one virtual autopsy is half an hour on an average, which is much lesser when compared to conventional autopsies.
3. There is no chance of organ trade as bodies are not cut open.
4. 3 Dimensional detailed viewing makes its possible to examine living beings after any weapon injuries for

measuring wound depth. In cases of deceased, it elicits the cause of death without human body manipulation.3 D facial reconstruction can even help in case of any medicolegal discords.

5. The samples collected are free of any contamination as there is no mutilation.
6. Virtual autopsy can be applied for many forensic situations like thanotological investigations, carbonized and putrified bodies.
7. Can be very useful for mass disaster cases, wherein the bodies are severely mutilated.
8. It can help if any case requires age estimation.
9. Anthropological examinations like mummies
10. In case of death by drowning CT can help establish the diagnosis.
11. In cases of bullet injuries where there is only entry wound and no exit wound and bullet is lodged in vertebral column where conventional autopsy can't determine its location.
12. In forensic odontology cases, post mortem data collection helps in positive identification. Post mortem data is compared to Ante mortem data to establish identification.
13. The digital storage of the data makes it to be used when required with precision.

Demerits of virtual autopsy-

1. It demands higher cost of the set up and maintenance.
2. With virtual autopsy one cannot determine the changes in colour , smell , texture of the tissues inspected and certain times, even the small tissue injury.
3. It fails differentiate between infectious status, pathological conditions and AM or PM trauma.
4. It is a highly technique sensitive imaging, thus demands skilled and expertise radiologists.
5. We need to turn the body for surface scanning, so the body shape can alter with it.
6. Feasibility of this imaging is questionable as judiciary acceptance of this technique is limited.

Method of virtopsy [18]

This imaging procedure fuses 3d imaging technique and 3D surface scan mapping the body's external scan, thus recording and documenting 3D images of human body in detail. In performing virtual autopsy, the first step is preparation of corpse, for which small disks are placed along the external surface of the body, so as to easily align surface and interior scans. The disks placed highlight points rendering images which are then converted into a single cohesive image. The use of Virtibot or robotic machines prevents any personnel discrepancies and promotes accuracy by placement of markers on body surface. Computer processors utilize markers to calibrate the corpse's exterior scan and match it with internal imaging processes. A 3 D color model is created after the placement of markers. Stereoscopic cameras, with a resolution of 0.02 mm are utilized to capture color images and a mesh pattern on the body is obtained. Within 10 seconds, the process of a 3D image construction will be completed.

After completing the surface scan, body is covered in a bag to avoid contamination then and placed in CT and MRI machines. The body is then scanned which will ensure privacy of the body, hygienic environment and meanwhile does not disturb the non-forensic personnel. After scanning, around 25,000 images are acquired within 20 seconds, with each image sliced through the body. Then the corpse is exposed to MRI and MRS scans. The information obtained from the scans are then processed in computers having draft style programs and powerful graphics processors. The data is processed to construct detailed, crisp images of bone and tissue made from X ray slices. 3D visualization is made possible because of the different quantity and absorption levels for foreign substances and body objects. Density differences make for varying colors, such as red for blood vessels, beige for sot tissue, white for bony structures and blue for air pockets. With just a click of mouse, pathologists can peel through layers of skin and muscles created virtually. Radiologist then deciphers the images by rotating at various angles, while studying the pattern. A needle biopsy if required to assess internal body samples is taken. The scanned data is captured and saved in CDs.

Vital reactions in virtual biopsy

Post mortem imaging poses an issue with vitality of injury, wherein difficulty arises in identifying time or occurrence of the injury - either during life or after death. Commonly encountered vital reactions are hemorrhages, aspiration of blood, water and gastric contents, inhalation of gases such as carbon monoxide, inflammatory responses and embolism. Though certain lesions such as gas embolism and hemorrhages can be detected with CT guided biopsy, inflammatory and fat embolism diagnosis can be made only by histological examination.[19,20]

Medical malpractice and Virtual autopsy

Medical technology advancements has raised issues of medical liability. With increasing awareness among the general public, medical liability litigation has surfaced posing greater risk for medical practitioners, particularly in case of physical injury or

death following therapy. Weman et al in 1997 was able to detect complications in coronary arterial grafts placement via post mortem angiographic method. Of the 223 patients evaluated with PMCTA, 122 (54.7%) demonstrated complications with graft or anastomosis. Postmortem angiography presented 100% diagnostic accuracy in detecting of twisting or narrowing of anastomosis, which would have been impossible even with autopsy dissection.[21] Wang et al reported a patient succumbing to cardiac rupture following pacemaker installation using PMCTA. A high resolution, 3D print model was obtained on surface scan which precisely reflected injuries and differentiation of anatomic areas. The findings in this case were presented to jury as legal evidence. [9]

Bioethical aspect of virtual autopsy

Privacy of data is the prime ethical issue arising in examined corpses. Aghayey et al. justified the security of privacy by an operational program guaranteeing anonymisation before transferring the considered data.[22]

Success rate of virtual autopsies

In 2018 one article was published in Journal of Pathology Informatics which states that there is accuracy of 65% in establishing the diagnosis of death with virtual autopsy. In this study 25 cases were examined both with virtual autopsy and conventional autopsy. So in 15 cases virtual autopsy rightly set up the diagnosis but in rest 8 cases conventional autopsy was used to set up the diagnosis. Virtual autopsy was very much useful in traumatic injury cases.So the validity of virtual autopsy as a diagnostic tool was higher for inferring both cause and manner of death.[23]

Where India stands in virtual autopsy

Most of the western world and certain countries of South East Asia region have adopted the virtual autopsy. India has started this facility at AIIMS New Delhi on 20th march 2021.[24] Computerized Tomography machine generates 25000 images in few seconds and it makes autopsy non invasive and less time consuming. India is in process to expand this facility in various states so autopsy becomes easier and to interpret the findings at the earliest. NEIGRIMS Shillong is another institute where virtual autopsy is shortly going to start as they are in the advanced stage of possessing PMCT. AIIMS Rishikesh has also started the process of possessing CT machine and to start Virtual Autopsy so many can be benefitted.

In 2016 AIIMS New Delhi had adopted digital x-rays and is functional which is used for firearm deaths , blasts injuries, penetrating injuries and hidden fractures .In covid -19, India we have witnessed a case of virtual autopsy where a 29 year old male was brought dead in New medical college Kota his father was suspicious of his death , so doctors performed virtual autopsy and found severe pneumonia was the cause of death . So virtual autopsy proved so useful that without cutting the body cause of death was established and there was no chance of spread of COVID -19 infection.[25]

Conclusion

Virtual autopsy or Virtopsy enables 3D construction of images or models, with clarity and simplicity. This technique has become a popular field in forensic sciences globally encompassing principles, equipment and concerns of digital technology. It allows for evaluation and assessment of human injuries effectively and enhances quality of identification for laymen. It is an emerging discipline with a promising future.

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REVIEW ARTICLE

Consumers and dental profession

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Abstract

Consumers today are increasing aware of their rights and the existence of consumer protection act. The dental profession is always regarded as a noble profession protecting health through oral health and preserving the integrity of oral cavity. With betterment in dental materials and increased understanding of the disease process, the dentists are at stress to render a standard care. The patient must lie his trust and confidence in the dentist. Legal issues arise because of universal accessibility to information. Hence, the dental health professional must be aware of their duties and rights in medico-legal concerns.

Keywords

Negligence; Consumer; Consumer Protection Act; Dental records; Consent

Introduction

Negligence in health care is a growing menace, which coupled with increasing awareness among general public has posed a great challenge to health care sector. Hospital authorities are frequently questioned about facilities, professional competence standards and relevance of diagnostic and interventional methods. Negligence, in dental practice can occur at times of history taking, diagnosis, intervention and after intervention instruction. Negligence cannot be equated to judgment error, but a deviation from providing reasonable care, considered to be within the competence of the dentist.[1,2]

With increasing consumer awareness about their rights, the frequency of cases charged against dentists for negligence is also on the raise.[3] However, claims from oral surgery and fixed Prosthodontic procedures were highest as reported by Milgrom P et al.[4]

Dental litigations

Dental practice today is prone to litigations in every phase. The common factors under which a dentist can face litigation include, failure for specialist referral, refusal to fee return in case of discontinuation, surety of a result, performing procedures beyond competencies, failure to obtain informed consent, either being unavailable or inaccessible to a patient during treatment phase, failure to properly diagnose and promptly treat a pathological condition, improper drug prescription…. to name a few.[5,6] Overall, to sum up in a nut shell, a dentist is charged if he or she fails to meet a reasonable standard of care. But the concern here is, are dentists really prepared for this. The dental curriculum does not elaborately teach or implement litigations arising due to negligence making the dental students kind of unaware to the situation. Also, the poor maintenance of dental record and lethargic approach in obtaining written informed consent further add up to this problem. Dental professionals are yet in the process of preparing for litigation in terms of cost and time. Time in terms of deposition, presenting supporting records or documents and discussions with attorneys and accountants is indispensible. Income loss in terms of absence from work and the reputation which follows resultantly is too damaging. Hence, it calls for a thorough understanding of law governing dental negligence and malpractice – The Consumer Protection Act.

Terminologies[7]

Certain terminologies need to be understood for better conceptualising the present review.

a. 'Consumer' refers to any person who hires or avails any services for a consideration which has been paid or promised or partly paid and partly promised or under any system of deferred payment
b. ‘Service' refers to service of any description which is made available to potential users. Health care services will be service, if they are obtained for consideration.
c. ‘Complaint' refers to any allegation given in writing by a complainant that the services hired or availed of or agreed to be hired or availed of by him suffer from deficiency in any respect.

Negligence

Negligence is derived from Latin word “neglego” means

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neglect or culpable carelessness. As per the Supreme court of India ruling, any act is considered negligent if either of the below mentioned is found;

- Dentist certainly owes a certain standard of care
- Dentist breached the standard
- The breach in turn resulting in injury
- An establishment of proximate connection between act of negligence and resultant damage.

Consumer protection act

The Supreme Court of India on 13th November 1994, delivered a landmark judgement to extend the CPA of 1986 to health care sector including doctors and dentists, nursing homes, private clinics. This empowers patients to file law suits in consumer forum, in case of negligent acts.[8]

Consumer protection Act 2019[9]

Section 2 (42) of the CPA 2019 contains a phrase "includes, but not limited to " and the same is an inclusive clause . It directly points to the fact that 'Healthcare' is still included and interpreted under section 2 (42) of the CPA 2019 (Which came into effect on July 24th 2020)

Any matter in medical negligence on the part of the service provider will be considered as deficiency under section 42 (11) of the new consumer protection act 2019. Any aggrieved person can claim damages for medical negligence against a doctor or a hospital.

Any act performed beyond the competency of the dentist or failure to perform an act considered reasonable in a situation constitutes dental negligence. Dentist patient relationship is founded on confidence and trust. Yet, when patients are not satisfied with their treatment outcome or progress of the treatment, they approach a legal body. Earlier, the law of Tort addressed dental negligence. But now CPA covers it to ensure speedy redressal and affordable justice.

CPA envisages all health care sectors providing treatment by health professionals for a pre-determined fee structure, but spares those institutions and professionals providing free treatment to all their patients.

Consumers Rights

1. Patient has right to know about all facts about her/his illness, medical records, made aware of risks and side effects.
2. During physical examination patient should be handled with consideration.
3. Patient has the right to know about doctor's qualification.
4. Patient has the right for complete confidentiality.
5. If patient has any doubt about treatment, patient has right for second opinion.
6. Patient has right to be told about any operation suggested and risk involved.
7. If patient is discharged or moved to some other hospital, patient has the right to make decision.
8. Patient has the right to get her/his case papers on request.

Consumer forums are set up as three tier structure; at the district level, state level and national level depending on the amount of compensation claimed.[10]

i. District forum addresses for a compensation of upto 1 crore claim and is chaired by a district judge and two expert panel members, of which one is a female candidate. Currently, a total of 569 district forums are functioning in the country.

ii. State redressal judges for a compensation claim of 1 crore till 10 crore , and headed by a high court judge. 32 state commissions are operational in this regard.

iii. National commission, set up in New Delhi addresses a compensatory claim of greater than a 10 crore.

The consumer can file a complaint in any of the above forums within 2 years of last treatment obtained. He / she can even appeal to higher consumer forums in case of dissatisfaction, within 30 days from the date of judgement.

Liabilities

Dentists under legal aspects are liable under the below said headings[11]

1. Tortious liability: It is of two categories –

a. Primary tortuous liability - which occurs when a dentist is held liable directly for a negligent act in his or her practice or a hospital. The compensation for this is non - liquidated damages as decided by the judge, in the form of cash compensation.

b. Vicarious liability: Dentists who are employed in organisations or hospitals are not charged for negligence. The hospital for which the dentist work is considered liable for negligence.

2. Contractual liability: The acceptance of a patient by a dentist upholds an implied contract and a breach in this aspect, with the dentist obliged to continue treatment without terminating either till cured or upon discontinuation by patient, is regarded as contractual liability.

3. Criminal liability: This form of liability is penal and

involves punishing in imprisonment form or a fine or both. Negligence of criminal type is regarded as a crime to both society and aggrieved party.

4. Statutory liability: A dental professional becomes liable with any statutes infringement. They are then held accountable by the statutory organisation. Liability depends on the form of infringement and statute provision.

Dental cases which are studied

Case 1: PRG Menon versus Dental Care – Compensation against dental negligence[12]

The complainant, Mr.PRG Menon was advised root canal therapy, followed by zirconia crown, on presenting with the complaint of tooth ache. The dentist had assured the patient 10 years warranty at the time of placement. However, the crown got displaced while brushing the following month. On reporting to the dentist, it was refixed and further reassured regarding its retention. Despite this, the next week itself, the crown got displaced again while having food. The dentist declined his previous statement and advised the patient to get re-treatment (Re - RCT). A complaint was filed against the defendant dentist for false assurance and wrong treatment.

Discussion- Res Ipsa Ioquitor - The refusal to honour complainant's claim accounted to gross error, negligence and deficiency of service resulting in improper procedural manner was upheld in this case. The case also stressed that obtaining consent before procedure is not enough, if adequate treatment is not provided. A compensation of 10,000/- Rupees for mental trauma and agony along with the reimbursement of the bill 20800/- Rs for treatment and 5000/- Rs for litigation charges were charged, which was payable within 30 days from the decision.

Case 2: Dr. Anirudh Agarwal versus Mr. Dharam Bir Bhatia[13]

Mr.Dharam Bir Bhatia filed a complaint in the district consumer court on behalf of his daughter, Miss.Nitu in 2007. The complainant argued that as per the advice of Dr.Anjali Dave Tiwari, the first oral physician, his daughter started with an orthodontic treatment from Dr.Anirudh Agarwal, the second oral physician, for which a total sum of 14000/- rupees was paid in instalments. The complainant filed a case of negligence against both dentists stating that the treatment provided to his daughter was not only incomplete and insufficient but put her under tremendous physical pain and mental agony, also affecting her growth.

District forum dismissed any charges against the first dentist as she had not charged any fees for consultation purpose. Meanwhile the second physician was held guilty for which a compensation of 25000/- rupees along with litigation charges of 3000/- rupees was slammed. However, the defendant appealed against the district consumer's decision in State forum, which further upheld the order of District court. The defendant further challenged this decision in the National redressal forum claiming that the patient missed several appointments in her treatment schedule. Also, the prognosis of her impacted canine involving orthodontic treatment was not assured wholly to the patient while explaining. An expert panel of 3 doctors was set up to verify the claim and found that the patient had actually missed several appointments and failed to show any evidence of negligence.

Discussion- The case against the second physician was dropped in 2013 upholding the judgement of "***Bolam vs. Frien Hospital Management Committee" [reported in (1957) 1 WLR 582]***, which held that a doctor is not guilty if he or she has acted with reasonable degree of skill and care and adopted practice, considered proper by a responsible body of medical men, skilled in that particular art.

Record maintenance: The dentist capability to produce records of patient not keeping up with appointments highlights the importance of record maintenance in dental clinics.

Case 3: Dr.Rajesh Gupta Versus Mr.Mohan Lal Gupta[14]

This case was a revision petition of a complaint in 2012, adjudged by the district consumer forum wherein, the complainant Mr.Mohan Lal Gupta alleged negligence during construction of artificial dentures by Dr.Rajesh Gupta. The court favoured the complainant and ordered a compensation of 10,000 Rupees for mental agony faced, along with refunding of the 3500 rupees charges taken and 2100/- rupees as litigation expenses. The dentist challenged the district forum's decision and appealed in State redressal court. The consumer forum ordered both the parties to appear before the court in 2013 for consideration of certain points and discussing evidences.

Dentist can be charged for negligence not only for inappropriate treatment, but also when the patient remains dissatisfied with the outcome of the treatment.

Case 4: Dr. Pawan Kumar Aryan versus Registrar, Dental Council of India along with Dr. Chander M. Kakkar, Dr.Vinod Chandail, Dr.Sumit Grover [15]

The complainant, Dr. Pawan Kumar Aryan filed a case of unethical medical intervention against all the defendants in 2016. The complainant alleged that following the implantation of some structure inside his jaw and administration of injection, he felt unexplainable body pain, which further worsened to the condition of breathlessness and restlessness in 2014. The

defendants did not take any necessary action when approached. Following which, the consumer went to multiple clinicians for 2-year period without any relief.

Discussion

A case of carelessness and professional misconduct was charged against all the dental practitioners, stating their failure to safeguard the consumer's interest.

The consumer forum upheld a decision that the grievance of the complainant was to be addressed in the State Dental Council, with first defendant being unnecessarily dragged into it. In case of ethical breach, as per the Dentist Act 1948 and Revised Dentists Regulations 2014, the petition by the aggrieved party must be before the State Dental Council constituted Ethical Committee. Hence the complaint was dismissed against the first defendant.

Subsequently, even the case against the rest of the defendants was dropped. Though the complainant pleaded that his first molar in the lower jaw was removed due to negligence of dentists, the claim was not sustainable as the medical records did not prove any misconduct from the professional aspect.

Preventive measures to be followed against litigation

The dentist has to follow certain dos and certain don'ts to avoid any unnecessary legal hassles in his / her dental practice, especially important if there are pre-existing complications present or likely to occur.

Dos to be followed-

- Always mention the qualification on the prescription form.
- Always make a mention of time and date of consultation.
- Clearly mention the particulars on such as age, gender and weight, if it is a child patient.
- Whenever complicated cases are suspected, precisely record history of present illness and substantial physical findings regarding the patient on the prescription form.
- If patient refuses the proposed treatment, get written informed refusal for the same in a language understandable to the patient along with proper witness.
- Strict avoidance of vague or non specific terminologies. Always make a note of patient's condition specifically and objectively.
- While prescribing drugs, use appropriate dosages and generic names.
- Any post- interventional instructions, if have to given such as diet restriction, rest, avoiding smoking and alcohol etc. must be given clearly. Also, it must be noted down separately in the case sheet form which will serve as a record.
- If prognosis is unfavourable for a proposed line of treatment, it is always better to explain it in a comprehensible manner and take consumer signature to avoid any future issues.
- In situations wherein intervention deviated from the standard care, explain it clearly to the patient and make a note of it.
- In case of non- availability of the consulting dentist, do make a mention of which dentist to be contacted in case of an emergency situation arising.
- Make a note if patient reports to clinic under the influence of alcohol or substance abuse.
- Also, maintain records of follow up of every patient and patient compliance in adhering to the proposed treatment protocol.

Don'ts to be followed:

- In case of expert assistance required, do not hesitate to contact colleagues or seniors.
- Keep the patients and family informed regarding the progress of the treatment and if any deviation from proposed treatment is expected.
- Never prescribe any indigenous medicinal system formulations (homeopathy or ayurvedha)
- In case of ill health or under influence of alcohol or exhaustion, never examine a patient.
- Never speak ill about your colleagues and maintain professional ethics.
- Never experiment upon a patient.[16]

Record documentation

Dentist records forms both a business and legal document, carrying more weightage than the testimony heard in the court. The dental record must include information relating to patient demographics, medical record of both present and past events, dental history, complete documentation of diagnostic tests, informed consent and informed refusal document, drug prescriptions, missed appointments and payment protocol. All records must be neatly and legibly written and accurate with no overwriting.[17,18] The dentist has an obligation to consult the attending physician of the patient he or she is treating prior to commencement of treatment, to obtain information regarding antibiotics or anticoagulants posing drug interaction risks.[19] Records needs to be maintained for a minimum period of 3 years after the last date of treatment. Premature destruction or loss of records, termed as 'Spoliation' can reduce the chances of avoiding negligence or any tortuous conduct against the dental provider.[20]

What to do in case of litigation?

In case of being sued by a patient, the dental practitioner need not panic and simply follow basic procedures. The dentist at first has to approach an attorney with all the records pertaining to the patient including informed consent. Make copies of the records to protect yourself. Instruct the team to never share any information regarding the patient to anyone outside. Never ever proceed for out of court settlement. Whenever called for, promptly appear with all records asked for. It is important to understand that records carry greater significance than verbal accusations.

Conclusion

Dentists must ensure a certain standard of care in their clinical practice with strict adherence to both legality and ethical aspects. This benefits both the dentist and consumer; the consumer rights are safeguarded and the dentist's reputation is on high. Consumer protection act enforced by the Supreme Court of India to health care sector is a crucial measure in reforming the dentist patient relationship, which in turn, also benefits the society and community at large.

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REVIEW ARTICLE

Telemedicine practice guidelines in India: Medico legal implications

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Abstract

Providing in-person healthcare services is challenging, especially in a vast country like India, where most of its citizens reside in the rural area. In this scenario, telemedicine can provide faster and timely healthcare services to the needy ones where distance is the critical factor. Healthcare seekers need not travel long miles for obtaining treatment and consultation. In most situation, telemedicine services are beneficial to the patients. A person staying in far remote area may access healthcare facility through telemedicine, thus avoiding issues related to mobility of the patient especially in elderly and debilitated patients. On the other side, telemedicine has its own limitation due to its virtuality. The person staying in remote area may not have access of tools required to access telemedicine facility. Internet connectivity in remote area is another issue. Telemedicine services could change face of providing medical services to the person residing at distant or in remote area if implemented effectively. Proper infrastructure is must to achieve this target. Information technology related instruments and services needs to be strengthened up at grass root level to provide better coverage of telemedicine facilities to needy ones. Telemedicine provides the safety of physicians and the patients, especially where there is a high risk of infection spread, such as in the present COVOD-19 pandemic. Mainstreaming telemedicine in the health system will improve the efficiency and outcome of the country's healthcare system.

Keywords

Telemedicine; Health; COVID-19

Introduction

World Health Organization defines telemedicine as "The delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communications technologies for the exchange of valid information for the diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and the continuing education of healthcare workers, to advance the health of individuals and communities."[1]Providing in-person healthcare services is challenging,especially in a vast country like India,where most of its citizens reside in the rural area. In this scenario, telemedicine can provide faster and timely healthcare services to the needy ones where distance is the critical factor. Healthcare seekers need not travel long miles for obtaining treatment and consultation. It has an important role, where there is no need for the patient to be physically present in front of the healthcare providers, such as regular follow-up and routine check-ups.

In most situation, telemedicine services are beneficial to the patients. A person staying in far remote area may access healthcare facility through telemedicine, thus avoiding issues related to mobility of the patient especially in elderly and debilitated patients. This provides a convenient way to interact with healthcare professionals in a timely and cost-effective manner. Distance is always a limiting factor to get access to healthcare facilities by the patients. Thus, telemedicine helps to increase number of new patients availing telemedicine facility. It is much more important in case of follow up because traditionally, physical follow ups tend to be lesser in compare to telemedicine services.[2, 3]

On the other side, telemedicine has its own limitation due to its virtuality. The person staying in remote area may not have access of tools required to access telemedicine facility. Internet connectivity in remote area is another issue. Further, it is not possible to assess patient physically by the doctor through telemedicine which may affect the proper and complete examination of the patient. Maintaining confidentiality of the patient information is another issue through telemedicine.[3, 4]

Telemedicine services could change face of providing medical services to the person residing at distant or in remote area if implemented effectively. Proper infrastructure is must to achieve this target. Information technology related instruments and services needs to be strengthened up at grass root level to provide better coverage of telemedicine facilities to needy ones.

During a disaster or pandemic like the current COVID-19, pandemic telemedicine can play a vital role in providing timely treatment and care to all affected persons. Though it will not solve all the health-related problems, it will take care of the people without an actual in-person consultation. Telemedicine

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practice can prevent the spread of infection in such a pandemic. Unnecessary exposure to the infected person can be avoided by telemedicine practice. But telemedicine practice will also have specific inherent medico-legal implications as in inpatient consultation and some unique medico-legal issues arising out of teleconsultation. Therefore, it is crucial to understand the medico-legal consequences of telemedicine practice, especially in India.

Current legal status in India

Globally, telemedicine services are being used by many countries. For example, National Telemedicine Guidelines were framed in Singapore to ensure comprehensive approach to provide healthcare to the patients.[5] European Union has also included telemedicine as a mean of healthcare services.[2] The Health Professions Council of South Africa has issued 'General ethical guidelines for good practice in telemedicine' that compels doctors to provide such services when in-person consultation is not possible.[6] Laws related to telemedicine are prevalent in many States of United States of America such as State of California, the Telemedicine Development Act of 1996; the Louisiana Telehealth Access Act, in the State of Louisiana, and Minnesota's Medicaid program enable patients to reimburse their expenses under telemedicine.[7]

Till recently,there was no legislation to regulate the practice of telemedicine in India. The existing legal provisions made under Drugs & Cosmetics Act (1940), Indian Medical Council Act (1956)[i], Information Technology Act (2000),Indian Medical Council Professional Conduct, Etiquette and Ethics Regulation (2002), Clinical Establishment (Registration and Regulation) Act (2010)[i] and Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules (2011) primarily dealtwith the practice of medicine concerningweb-based information technology. The Indian Medical Association (IMA) also sought clear-cut guidelines from the Medical Council of India (MCI) on telemedicine.[3]

The Board of Governors had issued "Telemedicine Practice Guidelines"on 25 March 2020, enabling registered medical practitioners (RMPs) to provide healthcare using telemedicine.[5,8]This is the first of its kind legal document allowing the practice of telemedicine and these guidelines are applicable to all registered medical practitioners who are working in the jurisdiction of India.[5]

Physician-patient relationship

The physician-patient relationship develops when a patient approaches any physician to seek treatment, and the physician accepts him/her as a patient. This is a well-known phenomenon in routine in-person consultation. But the question is whether this also applies to telemedicine practice? Yes, the answer is that in any way,a request is made by the patient himself or through a healthcare provider to other healthcare professionals or facilities on the electronic platform. The recipient healthcare professional has to accept an online consultation request before proceeding.Connecting patient to the doctor through telecommunication medium has its own problem like connectivity, user exposure to tele-devices, confidentiality of patient records etc. The patient may not feel connected to doctor thus may affect the purpose of telemedicine. However, the patients from remote area or the elderly/debilitated patient may get most benefit as telemedicine provide access to healthcare without compulsion of physical presence. Thus, telemedicine practice also allowed for the development ofthe Physician-patient relationship, with the same set of duties and responsibilitiesas in traditional practice

Informed consent

Consent from the patient before starting any treatment is the key to avoid any future litigation in the court of law.In India, any person whose age is twelve year or more can give valid consent for examination or any medical procedure after considering provisions mentioned in section 87 to 92 of Indian Penal Code (IPC). Same provisions are also applicable in case of telemedicine practice.[9] Implied consent is applied whenever any patient visits the physician for treatment. This also applies tothe patient's simple general examination; informed consent, on the other hand, is taken before implementing any specific treatment or testing. Telemedicine is a unique situation where there is no in-person consultation. Awareness amongst the people in the country regarding telemedicine is deficient, especially in rural areas. That's why it is essential to take specific, informed consent while dealing with a patient on the electronic platform. A physician must inform the patient regarding various restrictions, pros, and cons of telemedicine, to whom to call in case of emergency, and their right to withdraw consent at any given point of time. The online consent form can also be filled before starting consultation, which the physician can sign digitally. A scanned copy of the signed consent form can also be collected from the patient. A video recording of the consultation or consent can be another alternative.[10]

Evaluation, management, and continuity of care

Telemedicine allows physicians to evaluate and manage the treatment protocol of the patients. But, many times, it is necessary to examine the patient to decide the treatment strategy. These areas are pre-defined by the present guidelines. For example, First Consultation means the patient is consulting

for the first time with the registered medical practitioner or has asked with the same RMP earlier. Still, more than six months have elapsed since the previous consultation, or the patient has consulted with the RMP previously, but for a different health condition. Follow-Up Consultation involvesdiscussion with the same RMP within six months of his/her previous in-person consultation. However, if the patient develops new symptoms that are not in the continuum of the last health problem; and/or RMP is not able to recall the context of previous treatment and advice. If the physicians canmanage the telemedicine cases, they may proceed with a professional judgment to provide health education counseling related to specific clinical conditions; and/or prescribing medicines.The treating physician must ascertain the identity of the patient during follow up cases.[5]

Referrals for emergency services

The patient's condition needs toassessed quickly by the physician based on available information given by the patient/relatives or other healthcare workers. The physician has to decide whether the condition falls within the emergency category. If it is an emergency, the goal should be to provide the earliest in-person consultation. However, critical lifesaving first aid protocol must be provided to the patient, followed by appropriate referral guidance. If the teleconsultation is being done with a health worker's help, he must provide first aidand refer the patient for propertreatment and care. When such an alternative in-person consultation is available, the physician must not go for treatment beyond first aid. However, teleconsultation might be the only way to provide timely care in the absence of alternative care.

Privacy and confidentiality of the patient records and information

Physicians come across various health-related information of their patients during the consultation, such as drug history, sexual knowledge, testing for STDs, family history, etc. Every such patient has the right to keep information private and confidential. Hence, every physician must maintain a patient's data privacy and confidentiality, which they comeacross during their treatment. This also applies to the telemedicine practice. According to the guidelines, the RMPs are allowed to use the various online platform, including social applications, i.e., Facebook, WhatsApp, etc., to be used for telemedicine consultation. But such requests are not managed by the government or agencies approved by the government. In case of breach of security, who will be responsible and liable for the damages is not clear. These sites and platforms are maintained by third parties originatingfrom countries other thanIndia. These guidelines have expressly excluded specifications for hardware or software, infrastructure & maintenance, data management systems involved, standards and interoperability, and digital technology use to conduct surgical or invasive procedures at a remote place. But, for the privacy of data, this has to be ensured by the government. Who can have access toa digital platform to provide telemedicine also need specific guidelines to protect the physicians' rights and the patients?

Issues of liability and negligence

The issue of liability and negligence arises when the physician-patient relationship is established. There is a breach of duty on account of a physician in combination with damage and direct causation. When all thesecomponents are present, the patient and/or his relatives can drag the physician to the court of law. The same principle also applies to telemedicine practice. Ifthe RMP has committed negligence during the telemedicine practice, he might face legal investigation. Previously, few cases have been reported in India, where the doctors were charged criminally due to the absence of specific telemedicine guidelines. In first case, three doctors and a nurse were arrested in a case of alleged medical negligence. One doctor among them who was arrested on the pretext that he was consulted over telephone during handling of a surgical case in some other hospital although he was not involved in the management of the patient.[11] In other case, a case of medical negligence was registered against couple doctors following death of a pregnant female. The allegation was that she was treated by the doctor through telephonic instructions to the nursing staff. Court took this incident as criminal and culpable negligence on the part of doctors.[12]

Licensure

According to guidelines, an RMP is entitled to provide telemedicine consultation to patients from any part of India. He has to follow the same professional and ethical norms and standards as applicable to traditional in-person care. An online program will have tobe developed to sensitize RMPs regarding electronic media use, a compulsory requirement for telemedicine practice in India. Till the time such a program/platform is designed, all RMPs can practice telemedicine in the Jurisdiction of India using whatever technology is currently available. But they have to be extra cautious regarding the security and safety of electronic-based platforms to avoid litigation while giving telemedicine services.

Litigation and Judiciary

In the eyes of the court of law, negligence is negligence,

whether arising out of in-person consultation or from teleconsultation. He might face legal inquiry in the court of law whenever the physician fails to follow standard treatment and care protocol. It is essential to adhere to ethical as well as statutory provisions ofthe country to avoid lawsuits. The court has accepted electronic media as proof of evidence according to the Information Technology act, 2008. This law has also given a secure digital signature legal recognition. So, proper documentation and keeping records of teleconsultation are the key to safeguard physicians' interests in the court of law.

Reimbursement

The RMPs can opt for professional indemnity insurance to cover legal costs and expenses incurred during defense in the court of law. It protects RMPs against a monetary claim from alleged negligence in the performance of professional services. This also applies to telemedicine practice. Presently, many companies have included telemedicine in their proposal. Any RMP has to get himself covered by medical indemnity insurance before taking up telemedicine consultations of any kind.

As far as reimbursement of medical claim for patient is concerned, The Insurance Regulatory and Development Authority of India (IRDAI) in its letter has asked general and health insurer to allow claim settlement for telemedicine consultation wherever normal consultation with a medical practitioner is allowed in the terms and conditions of the policy contract.[13]

Misconduct

It is the responsibility of the doctor to provide due care and treatment once the doctor–patient relationship is established. It is applicable in both situation whether is consulted physically or through telemedicine. It is the doctor, who has to ensure that no misconduct is being done to the patient. In case of any misconduct on telemedicine platform, the patients or his/her relative may initiate appropriate action against the doctor.[3]

Product Liability

It is the liability of manufacturers for any damage caused to the patient by a defective product. Thus, if any damage to the patient occur due to defect in tele device, it will be responsibility of manufactures for such damage. However, in recent act (The Consumer Protection Act, 2019)[14] apart from manufacturer the responsibility was also fixed upon the vendor who is supplying the product to the end user.

Rights of patients

Traditionally, the patients have the right to get treatment, right to choose a doctor, right to change doctor, right to maintain dignity and right to refuse treatment. The patient has right to get all his electronics records wherever and whenever he required. Such rights are also applicable in case of telemedicine practice.[2]

Artificial intelligence

Providing services through telemedicine may cause misdistribution of the demand and supply of services. Artificial intelligence (AI) may help to resolve this issue by developing algorithms to distribute demand and supply chain effectively. Sometimes, telecommunication link fails; in that case also AI may provide mechanism for human or virtual interaction between doctor and the patient. AI can support the development of clinical practice knowledge to the healthcare givers. AI can provide intelligent information and communication environment to the clinicians to provide better care to the patients.[15]

Conclusion

These guidelines are the first its kind document to regulate telemedicine practice in India. This is the need of the hourto provide healthcare facilities to the remotely located patient in the country, and telemedicine can help achieve it. Telemedicine also ensures the safety of physicians and the patients, especially where there is a high risk of infection spread, such as in the present COVOD-19 pandemic. Mainstreaming telemedicine in the health system will improve the efficiency and outcome of the country's healthcare system. These guidelines should be used in concurrence with the other national clinical standards, protocols, policies, and procedures. Physicians are advised to keep all electronic records with them as a safeguard to future lawsuits.

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REVIEW ARTICLE

Pathological autopsies in COVID-19 fatalities: An urgent need of the hour

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Abstract

With the advent of COVID-19 as a pandemic, researchers and medical communities have taken up the quest to answer many questions. The science of the 21st century is seen to rely more on genetically modified animal models and cell lines for understanding the virus-host interactions and pathogenesis. This has put a shadow on basic yet effective conventional ways of conducting autopsy studies, collecting tissue samples, and examining them under a microscope. In this very moment of crisis, researchers are advised to study the disease in its natural micro-environment. Though newer advances in science and technology can help us in constructing the road ahead but that road can tread us to blind ends, without the guiding vision provided by a pathological autopsy.

Keywords

Pathological autopsy; COVID-19; SARS Cov-2; Pathogenesis

Introduction

The emergence of the Corona virus Disease 2019 (COVID-19) pandemic has alerted the world of disastrous consequences, if not controlled with strict measures and science-backed solutions. World Health Organization on 11th March 2020, labeled COVID-19 as a pandemic following the reporting of COVID-19 cases from 114 countries.[1] Consequently, by the end of March 2020 over 100 countries worldwide had instituted either a full or partial lockdown, affecting billions of people.[2] It was identified that the causative agent has structural similarity to the virus that caused severe acute respiratory syndrome (SARS) in 2002 and was named as Severe Acute Respiratory Syndrome Corona virus-2 (SARS Cov-2).[3] Today, researchers have accumulated much knowledge regarding the pathogenesis and risk factors of COVID-19, in addition to developing targeted therapies and vaccines. It may seem as if the pandemic of COVID-19 is brought under control but the situation is far too complex to make such claims. Various reports on the emergence of immune-escaping COVID-19 variants, waning immunity over time with reports of infection in immunized healthcare workers, and fatalities following immunization speak of a greater challenge than imagined.[4–6] Pathology plays a vital role in the detection, surveillance, and research of diseases. Autopsy, in particular, has a special place when it comes to the identification and understanding of emerging and reemerging infectious diseases.[7] Recently we have seen that there is a decline in the number of pathological autopsies being performed across the globe and publications have appeared in the literature emphasizing its revival.[8–10]

This article reviews the literature about the role of pathological autopsy in understanding the pathogenesis of an emergent infection and recommends pathological autopsies in fatalities related to COVID-19.

Autopsy- importance and contributions

The importance of autopsy from a medicolegal standpoint can be easily appreciated, but this procedure does not limit itself to the forensic application only. It has served many roles in medicine: as an educator of the human body; as a guide for medical practice through diagnosis & quality assurance; as a body of science promoting research; and as a service provider catering to the needs of society by public health data.[8,9,11,12]

Autopsies have substantially added to our knowledge of emergent infectious diseases caused by HIV, Hantavirus, West Nile Virus and will continue to do so in the current COVID-19 pandemic too if given a chance.[9] Not only human autopsies but animal autopsies on non-human primates conducted by veterinary pathologists have contributed a lot in our understanding of diseases like Japanese and Venezuelan equine encephalitis, hemorrhagic fevers due to Ebola, Marburg, and Lassa viruses, etc.[7] In SARS (Severe acute respiratory syndrome) epidemic 2002, more than 60 autopsies are reported and initial autopsy data was published at the earliest which helped in defining the pathology and pathogenesis of the disease.[13–15] MERS (Middle East respiratory syndrome) affected 1500 individuals and caused >500 deaths in 2012 in the middle east. Out of 500 deaths, only one case with autopsy findings is documented in the literature.[16,17] The single autopsy description of MERS has served a great deal not only for comparing the

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pathological picture with other diseases like SARS but also in designing therapies.[17–19]

Utility of Autopsy in COVID-19

A careful microscopic study with immuno-histological and molecular techniques can only reveal the pathogenic activity of the infection.[9] To our understanding, an autopsy can prove to be a valuable tool in circumstances not limited to the following:

1. About natural history, pathogenesis, prophylaxis & management of COVID-19.
   a. Understanding the disease: The natural history & pathogenesis of a disease process play an important role in designing targeted therapies and also monitoring the patient during treatment.[19] There is enough evidence that SARS-CoV-2 binds to Angiotensin-Converting Enzyme (ACE2) receptors to gain entry into the lung cells. But apart from pulmonary tissue, ACE2 receptors are also highly expressed in other tissues such as the bile duct, liver, gastrointestinal organs, esophagus, testis, and kidneys.[20] In addition, COVID-19 is shown to cause cardiac manifestations, kidney problems, and neurological issues which are responsible for additional fatalities in admitted patients.[21–24] As these organs may also be damaged, a thorough examination of all bodily organs is necessary.
   b. Guide in management: An interesting therapeutic turnover is seen best in the following example: Physicians may advise against the administration of corticosteroids in a patient with pneumonia. But after seeing the pulmonary edema and hyaline membrane in the lung biopsies of COVID-19 patients, researchers have advised in favor of timely corticosteroid administration with ventilator support in severe cases.[18]
   c. Identify COVID-19 in fatalities with false-negative results: A meta-analysis has found that the sensitivity of RT-PCR is variable and dependent on the number of primers probes used in the assay. It has been predicted that 87% of patients dying with positive CT changes and negative RT-PCR results are Covid-19 positive.[25] The missed diagnosis of COVID-19 in absence of autopsy was realized by the researchers who conducted initial autopsies and autopsy data from RT-PCR negative cases has confirmed the presence of lung histopathological changes which are consistent and similar with COVID-19 positive cases.[26,27]
   d. Inter-population differences in disease trends: The variation of viral pathological interaction in different populations, if any, should also be thoroughly investigated to practice evidence-based medicine. The classical example includes observation of significant differences in the prevalence of anosmia in COVID-19 affected patients in the Indian and European populations.[28]
2. Lack of published autopsy research from India: Even after an extensive search, we have not come across any research publication on autopsy data from India despite witnessing 4,43,928 deaths due to COVID-19.[29] World Health Organization (WHO) in its road map to research in COVID-19 has kept autopsy as a priority research domain and has recommended for autopsies to be conducted whenever possible.[30] Indian Council of Medical Research had also realized the need for an autopsy in these cases.[31] Till date experts from All India Institute of Medical Sciences, Bhopal have conducted the first autopsy-based formal study in COVID-19 fatalities in India and their findings are yet to appear in the research publication.
3. The discrepancy between clinical and autopsy data:

   Too much reliance on antemortem and clinical data can have catastrophic results; as studies have reported a discrepancy rate in the cause of death in clinical and autopsy data to the tune of 10-30%.[11] In addition, a prospective autopsy study on critically ill patients has revealed an error rate of 18.9% with 7.2 % error being major and having a direct impact on therapy and outcome.[32]
4. Preparedness for the future:

   A global coalition with an inclusive approach is called for constructing a database encompassing inputs from clinical, pathological, and other research modalities; for lessons learned to handle situations of any future pandemics.[33]

The arguments against conventional autopsy

1. Virtopsy and recent advances in medicine replacing conventional autopsy[34]:

   CT-based studies are helpful in severity assessment, prognosis prediction, and even detection of RT-PCR false-negative cases.[35,36] Still its usefulness is limited when it comes to elucidating the pathogenesis of the disease process which requires a thorough examination of all organs and tissues.
2. Animal model and molecular studies for pathogenesis:

   As science began to give more branches, we have become biased to trust newer modalities and go directly to these upmarket fields, missing the savvy and conventional ways to solve problems. It is unfortunate that in this situation of a pandemic, researchers are directing their resources to study viral pathogenesis in transgenic mice (with human ACE2 coding sequence incorporated in wild mice) or on cell lines in a petri dish whereas actual human tissues from SARS Cov-2 deceased are sent for cremation.[37,38] Researchers are to be reminded that though animal studies are handy to study vaccines but should not be the only resort in face of an

unknown disease pandemic with such a wide and complex pathological spectrum. During outbreaks, clinical data has to be studied with autopsy information and parallel running animal model investigations to help in design therapies.[19]

3. Autopsy in COVID-19 can cause infection to the personnel in a morgue

   World Health organization in its interim guidance on dead body management has recognized the possibility of lungs and other organs harboring the live SARSCov-2 virus.[39] Recognizing this possibility, various scientists and organizations have put forward views and guidelines for the management of dead bodies and autopsy examination in a diagnosed or suspected case of COVID-19.[26,39–41] Health and Safety Executive's (HSE) Advisory Committee on Dangerous Pathogens (ACDP) has categorized the infectious biological agents into 4 categories (HG1-4) and SARS Cov-2 is labeled as a hazard group-3; where there is a risk of serious human infection but effective prophylactic or therapeutic measures are usually available.[41] In addition, this category includes other infections like Dengue, HIV, Hepatitis B, C, D, etc. where autopsies are still being performed on a routine basis. It is postulated that risks in most infections are minimal when standard universal precautions for infection prevention are applied.[26] Although, autopsy material has shown positivity for the viral genes even after 26.5 days after death from multiple tissues; no confirmed evidence has appeared to show infection to a person from exposure to the dead body of a patient dying due to COVID-19.[39,42]

Conclusion

Understanding the natural history and pathogenesis forms the first step to design targeted therapy and monitoring of COVID-19 patients. The natural micro-environment provided by autopsy material is superior in comparison to artificially create one, and we should direct our efforts to study techniques based on autopsy. Finally, performing a procedure involving aerosol production on a living COVID patient cannot be denied as it is unethical and involves a person's life. How is it ethical or justified not to perform autopsies, to gain knowledge to save many lives?

We recommend that all fatalities due to COVID-19 should be investigated in all its aspects including autopsies. The pathological advances that we make today, will serve as a guiding vision; and information obtained from these autopsies will form the skeleton of medical knowledge in dealing with future epidemics by the same or similar pathogen, which of course is a reality that one cannot deny.

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CASE REPORT

Skin and heart histopathology in fatal electrocution with otherwise inconclusive autopsy findings: A case series

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Abstract

The macroscopic evidence of low voltage electrocution in the skin is seen in the form of a crater with raised areolar edges and a surrounding pale area. This typical picture ofskin is mostly minimal or altogether absent in many cases of electrocution. The issue gets complicated in the absence of any eye witnesses or circumstantial evidences. Under such a scenario, it is advisable to do a histopathological examination of the suspected skin wounds. Since cardiac arrest is the most common mechanism of death following electrocution, heart histopathology may also yield vital evidence. We report three cases of electrocution. In one case, there were eye witnesses to the electrocution incident. In the second case the body was recovered from a swimming pool with no direct eye witness. In the third case the victim suddenly collapsed while welding. All the three cases were received dead in our hospital with inconclusive skin findings during autopsy examination.The histopathological examination of heart along with the skin wounds provides the vital evidence in favor of electrocution. Through these case reports we stress the importance of histopathologically examining the skin and heart in alleged cases of electrocution with inconclusive autopsy findings.

Keywords

Electrocution; Joule burns; Skin wounds; Histopathology; Myofibre break-up

Introduction

Electrocution injuries are caused by contact with either high voltage transmission wires or low voltage domestic current. The pattern of injuries noted in high voltage electrocution is usually appreciable during autopsy examination. But such clear cut findings may not be found in many cases of low voltage electrocution. Joule burns, which are classically described as entry wound feature of low voltage electrocution are not seen regularly.[1,2] In these cases doubt may persist in the mind of the forensic pathologist whether to mark them as electrocution entry wounds or not. Similarly, the exit wound is either absent or not clearly appreciable on macroscopic examination in some cases. In such cases, histopathological examination of the suspected entry and exit woundwhenever present should be considered essential. Cardiac arrest occurs most commonly when the current enters through the right hand and exits through the feet.[1,3] Hence, histopathological examination of the heart may also be considered essential where death occurs immediately after electrocution.

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Case report

Case no. 1

A do it yourself electrician accidentally got electrocuted and was immersed inside a swimming pool while repairing a faulty motor pump meant to drain out water from the pool. A suspected electrocution entry wound was noticed on the radial aspect of proximal phalanx of right index finger of size 0.7x0.2 cm. It was light red-brown in colour with well-defined margins. Two suspected electrocution exit wounds of sizes 0.6x0.2 cm & 0.4x0.2 cm were noticed on the sole of right foot. Heart, lungs and brain had normal findings. Tissues from the above skin sites, samples from control sites (contralateral hand and foot) and heart were sent for histopathology examination. The skin tissues showed focal destruction of keratin layer and highly eosinophilic appearance of keratin (Figure 1). Control site samples were histologically within normal limits. Section from heart showed mild myofibre disarray, interstitial congestion and edema, focal degenerating vacuoles with myofibre breakup (Figure 1). Histopathologically the other viscera were within normal limits.

Case no. 2

A brick kiln laborer accidentally got electrocuted when the metallic rod he was using came in contact with overhead electric wires. At autopsy, red-brown coloured skin lesion was noticed in the thumb of left hand and adjoining thenar eminence. No exit wounds were appreciated. Tissues from the suspected entry wound and heart were sent for histopathological evaluation. Section from skin showed hyperkeratotic epidermis, intra-epidermal separation with

nuclei of the epidermal cells exhibiting stretching and narrowing to produce palisading appearance (Figure 2). There was congestion with extravasation of RBCs along with vacoulation, separation and disarray of myofibres (Figure 3). Macroscopically and microscopically the other viscera were unremarkable.

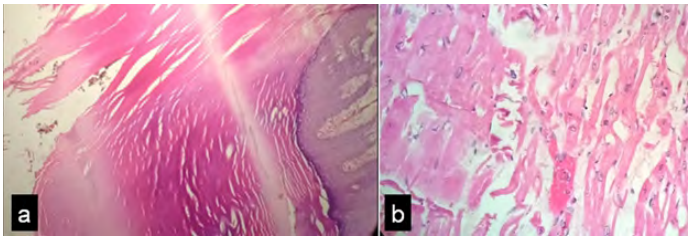

Figure 1: (a): Section from skin showing keratinous destruction and hyper keratinized epithelium. (b) Section from the heart showing myofibers disarray, interstitial congestion, oedema and myofibre breakup – H&E 20x

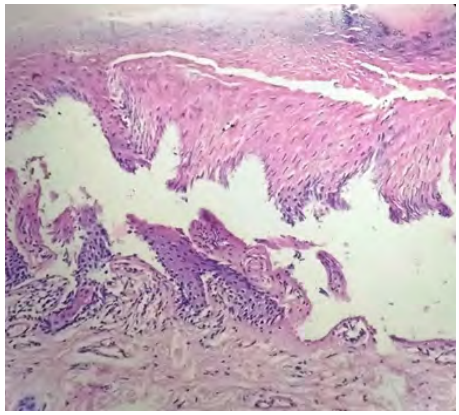

Figure 2: Section from skin shows hyperkeratotic epidermis with intra-epidermal separation with nuclei of the epidermal cells exhibiting streaming of cells – H&E10x

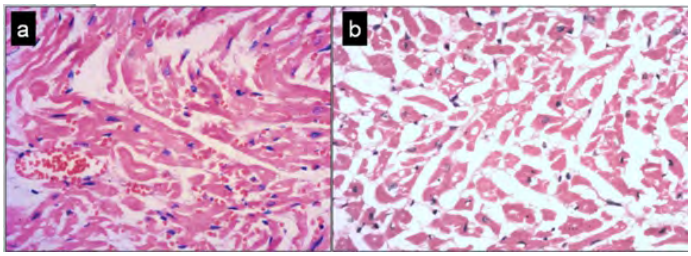

Figure 3: (a): Congestion with extravasation of RBCs in myocardium. (b) Myocyte vacoulation along with separation and disarray of myofibres – H&E 20x

Case no. 3

A 46 year old male had sudden loss of consciousness while involved in welding work in a factory. He was received dead in our hospital. He was not a diabetic or hypertensive and had no other long standing illness or co-morbidities. He was a chronic alcoholic for 20 years. On examination, red-brown coloured skin lesion of size 0.6x0.3 cm was noticed in the medial aspect of hypothenar area of right hand. Another skin wound in the form of a crater of 0.3 cm diameter was noticed on the dorsal aspect of medial side of right feet about 15 cm behind the tip of great toe. Section from skin of right hand showed intra-epidermal blister along with vacuoles and disruption of keratin (Figure 4). Histopathological examination of right foot skin showed vesicle at the dermo-epidermal junction and coagulative necrosis of both epidermis and dermis(Figure 4). Section from left heart showed few myocytes showing squaring of nucleus with bundles of hypercontracted and hyperdistended myocytes (Figure 5). Coronary vessel showed myxoid changes. Liver showed focal micro and macrovesicular steatosis, sinusoidal dilatation and congestion with focal nodular changes. However diffuse loss of architecture or nodule formation was not seen.Rest of the microscopic examination was unremarkable.

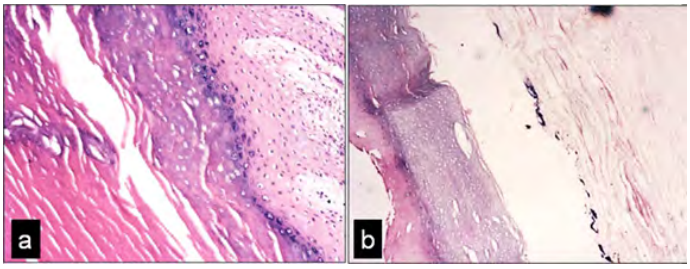

Figure 4: Skin tissue showing intrae-pidermal vacoules with disruption of keratin in (a) - H&E 10x; (b) coagulative necrosis of epidermis and dermis with dermo-epidermal separation - H&E 4x

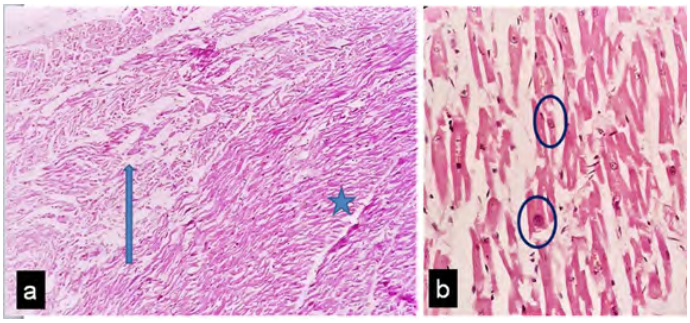

Figure 5: (a): Hypercontracted (star) and hyperdistended (arrow) myocardial fibres - H&E 10x. (b) Squaring of cardiac nucleus - H&E 40x

Discussion

Death in electrocution occurs following cardiac arrest, spasm of the respiratory muscles, paralysis of the respiratory centre, secondary causes like burns, infection, injury etc. Death by cardiac arrest occurs where the victim dies immediately following electrocution. Cardiac arrest occurs when the current passes through the thorax, from hand to hand or from hand to leg routes.[1,3] Maximum current flow (up to 8.5 % of the total body current to flow through the heart) occurs when the current passes from the right hand to foot. In two of our cases, the current entered through the right hand and exited through the

right foot. It is interesting to note that the entry and exit wounds were on the same side of body. Though, illustrations in few books seem to suggest that the exit will be from the opposite foot but the accompanying literature does not say whether exit wound will be located on the contralateral or ipsilateral side. It merely suggests that the maximum current flow occurs through the heart when passage is from right hand to foot.[1]Spasm and paralysis of the respiratory muscles occur when current instead of passing through the heart passes through the body surface.Paralysis of the respiratory centre occurs when current passes through the brain causing stoppage of respiration but the heart continues to beat.[1] In our cases, time of contact was less, death was immediate,entry wounds were in the hand, current did not pass through the brain and histopathological findings were observed in heart. Hence, paralysis of the respiratory muscles or centre was ruled out in our cases. The cause of death of these cases was opined to be due to cardiac arrest following electrocution.

The 'Joule burn' which is considered the cutaneous mark of electrocution, classically appears as a collapsedblister with raised margins formed from molten keratin. There is an areola of blanched skin at the periphery of this lesion. Often this blanched area is surrounded by a hyperaemic border.[1,2] In many cases fatal electrocution may occur with minimal or inconclusive skin findings. In all our cases, the macroscopic skin findings did not have the classical features of an electrocution entry wound. So circumstantial evidences had to be taken into consideration. In addition, we sent the skin tissues forhistopathological examination. The prominent skin features noted in electrocution are intra-epidermal separation, sub-epidermal separation, coagulation necrosis and nuclear elongation in the epidermis, dark staining of epidermal nucleus and depth of homogenization in the dermis.[4,5] These features occur because of the enormous amount of heat produced during electrocution and some of these features may be noticed during flame burns also.According to one study, intra-epidermal separation is most frequent in electrical lesions, and sub-epidermal separation is the most frequent finding in naked flame burns; a combination of both is most likely to be caused by electricity. The reason for this could be that electrocution injury produces more heat than flame burns in the tissues causing separation in the most resistant layers.[4] Most of the histopathological features mentioned above were noticed in our cases.

Baroldi et al. conducted a study to find frequency, location, and extent of myocellular segmentation of intercalated discs and associated changes of myocardial bundles and single myocells in sudden unexpected cardiac death cases. They postulated that myofibre break-up (MFB) can be considered as histologic marker of malignant arrhythmia which causes cardiac arrest.[6]The term MFB includes the following histologic patterns: (a) bundles of distended myocardial cellsalternating with hyper-contracted cells. Myocardial nuclei in the hyper-contracted cells have a “square” aspect rather than the ovoid morphology seen in distended myocytes.(b) hyper-contracted myocytes alternating with hyper-distended cells that are often divided by a widened disc. (c) non-eosinophilic bands of hyper-contracted sarcomeres alternating with stretched, often apparently separated sarcomeres. Another pioneering study was conducted to characterize the types and frequency of the structural myocardial injury in cases of fatal electrocution and determine whether MFB was more common in electrocution deaths.[7]They were of the opinion that MFB could be the result of passage of abnormal electrical currents through the heart. Other microscopic features of heart include disarray of myofibres with loss of nuclei, segmentation, vacoulation, congestion and extravasation of RBC's, interstitial congestion and oedema.[5,8]

The history provided by the investigating officer in the second case only was of alleged electrocution. In the first case, there were no eye witnesses and the deceased was recovered from the swimming pool. So the initial suspicion was that of drowning following a cerebrovascular accident or coronary artery disease. But macroscopically and microscopically no such evidences were found in the heart, lungs and brain. The possibility of his bare hand coming in contact with the live pin while removing it from the socket cannot be ruled out. In the third case, the person suddenly became unconscious while working with an electric welding machine and was received dead in our hospital. We visited the scene of the incident but could not figure out how he sustained the electrocution injuries in the hand and feet. He was a long standing alcoholic and his liver findings were suggestive of cirrhosis. Examinations of the other viscera were unremarkable. In all our cases, the classical skin findings of low voltage electrocution were absent. So next we had to consider the circumstantial evidences which were suggestive of electrocution deaths. Based on the history provided, we looked for electrocution injuries in the hand and feet. Skin samples from the suspected site, control site skin samples and heart were sent for histopathological examination. Hence, based on the history, circumstantial evidences, autopsy and histopathological findings we were able to conclude that death occurred by cardiac arrest as a result of electrocution. Though histopathological examination of skin is not considered 100% pathognomonic of electrocution, but combined with heart findings one can rule it in favor of electrocution.

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CASE REPORT

Traumatic scrotal emphysema: An underreported benign condition and a brief review of its mechanism

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Abstract

Scrotal emphysema, also known as pneumoscrotum, is an uncommon condition due to the subcutaneous accumulation of air in the scrotum. Air accumulation may be local, due to infection in the scrotum, or of distant origin from lung, peritoneal or retroperitoneal sources.In the present case, a twenty-seven-year-old patient was brought dead to the emergency with a history of road traffic collision. The patient sustained multiple injuries to the head, chest, and abdomen and the scrotum appeared to be distended with palpable crepitus. Subcutaneous emphysema of the chest and abdominal wall was absent. The presence of air in the scrotum was confirmed by visualizing the air bubble in a water-filled syringe. Though it appears to be a benign condition, efforts should be made to find out it's primary or secondary etiology. The traumatic causes of scrotal emphysema are underreported and receive little discussion in forensic pathology hence causes, and the mechanism of its development are discussed.

Keywords

Traffic Accident; Blunt Injury; Pneumoscrotum; Scrotal Emphysema

Introduction

Pneumoscrotum is a term used to express the presence of air in the scrotal layers and includes the term scrotal emphysema and pneumatocele.[1] Accumulation of air in the scrotal wall with palpable crepitus is known as scrotal emphysema, and non-palpable presence of air inside tunica vaginalis is known as pneumatocele.[2] Clinically scrotal emphysema presents with enlargement of the scrotum with palpable crepitus and loss of scrotal skin rugosity. The incidence of this condition is not very high because often it is considered a benign condition and is underreported.[1] Only a few cases of scrotal emphysema have been reported in the literature.[3] The main causes for its development are traumatic and iatrogenic in origin, and sometimes local infection or injection of air also contributed to it.[4] The pressure difference between thoraco-abdominal cavities and scrotal sac along with potential space in the scrotum are the main driving force for air to travel and accumulate in the scrotum.[3] We present an autopsy case report of traumatic scrotal emphysema to discuss its cause and mechanism of development.

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Case report

A 27-year-old male patient was bought to the emergency department with the history of a road traffic collision and he was declared brought dead. He was riding a motorcycle and collided with the car coming from the wrong side, and then fell away on the divider of the road. On external examination, multiple small reddish abrasions were present mainly over the face, head and back of the trunk. Few abrasions were also present over the limbs. Scrotum appeared distended with loss of skin rugosity and partially embedded penis with normal skin color (Figure 1). On palpation, crepitations were felt, and fluid thrill was absent. Further examination was conducted using a water-filled syringe without piston. Air bubbles were appreciated in the water when the needle was inserted deep into the scrotum, which confirmed the presence of air in the subcutaneous layer of the scrotum. Internal examination revealed fissure fractures at the base of the skull, and right-sided 3rd, 7th and 8thribs were fractures in the paravertebral region with associated underlying lacerations in the right lung lobes. The presence of pneumothorax was appreciated in the right side when opened inside the water seal; however, no presence of air was appreciated in the layers of skin of the thorax or abdomen. Internal examination of the abdomen showed multiple lacerations in the right lobe of the liver. Rest of the abdominal organs were unremarkable. We did not find any sign of local infection or trauma to the scrotum or its content. The cause of death was opined as multiple injuries sustained to the head, chest, and the abdomen as a result of blunt force impact, and the nature of the injuries consisted with the history of road traffic accident.

Figure 1: Diffuse scrotal emphysema as showing distended scrotum with loss of skin rugosity

Table 1: Causes of the pneumoscrotum

Pathological	Iatrogenic
• Pneumothorax (traumatic and spontaneous) • Pneumomediastinum • Thoracoabdominal trauma • Scrotal trauma • Visceral perforation • Fournier's gangrene • Perinephric abscess • Empididymo-orchitis • Autoerotic air injection	• Abdominal endoscopic interventions • Laparoscopic surgery • Open gastrostomy • Anastomotic leak after colonic resection • Renal surgery • Retroperitoneal sympathectomy • Pulmonary resection • Percutaneous liver and kidney biopsy • Tracheal intubation and assisted ventilation • Chest drainage insertion • Cardiopulmonary resuscitation

Discussion

The presence of air in the subcutaneous layer of the scrotum is a critical sign though appears to be a benign condition. The scrotum is a musculocutaneous pouch-like structure, and its wall is composed of (from superficial to deep) skin, superficial Dartos fascia, external spermatic fascia, cremasteric muscle, internal spermatic fascia, and tunica vaginalis. These layers are an extension of abdominal and perineal wall layers. The superficial fascia of trunk forms two-layer in the anterior abdominal wall, e.g. Camper's and Scarpa's fascia. These two-fascia fuse at the perineum and form Colles' fascia which continue into the scrotum as Dartos fascia. The innermost layer, tunica vaginalis, is an outpouching of the peritoneum.[5,6] In most cases of the pneumoscrotum, air travel along these superficial and deep fascial planes. Three possible pathophysiological mechanisms have been described in the literature regarding the spread or presence of air into the scrotum.

1. The spread of air along fascial planes of the trunk is considered as a most common pathway. The air diffuse and dissect along superficial and deep fascial planes of the trunk to follow the path of least resistance.[1,2] Here subcutaneous emphysema of the chest and the abdomen is the prominent finding though it may extend up to the neck or thigh. Another pathway for air to travel is through the retroperitoneal route. Pneumothorax can result in pneumomediastinum, and air can dissect along the diaphragmatic hiatus or sternocostal margins to reach into the perinephric space and cause pneumoretroperitoneum. Further air can reach to the scrotum by travel along the spermatic fascia or diffusion from the inguinal canal.[3,7]
2. The second possible mechanism is the intraperitoneal extension. Intra-abdominal air (pneumoperitoneum) can reach to the scrotum by diffusion along the fascial planes or through peritoneal defect or patent processus vaginalis which remains patent in about 15% of adult males.[2]
3. A third and less common mechanism is a scrotal infection or local trauma. Gas producing bacterial organisms can reach to the scrotum through the blood or lymphatic channels and may result in local gas accumulation. Direct scrotal trauma or injection of air in the scrotum for sexual arousal can cause direct air introduction.[1,8,9]

Many etiologies have been described in the literature for its development, and the first case was reported in 1912 following a nephrectomy.[10] The source of air in primary pneumoscrotum derives from scrotum itself and common causes are abscess/infection of scrotal wall or content, scrotal trauma, and autoerotic air injection.[1,9,11] Secondary pneumoscrotum is defined when the source of air is distant, and subsequently, air travelled to the scrotum. Most common causes include trauma to the chest; and following diagnostic and therapeutic interventions to the thoracic and abdominal organs causing iatrogenic injuries.[4] Spontaneous causes such as spontaneous pneumothorax, Gastro colic perforation, diverticulitis and necrotizing enterocolitis have also been reported. Less common etiological factors are cardiopulmonary resuscitation, prolonged assisted ventilation, and rarely, cause is uncertain.[1-4] Various pathophysiological causes are summarized in Table 1.[1-4,7,9]

A search for distant pathology should be made when local trauma and infective causes are not present. History of any recent medical illness or surgical procedure helps identify the underlying etiological origin and also in excluding other acute scrotal pathologies such as infection of scrotal content, trauma, neoplasm, torsion, hernia, hydrocele, and hematocele. For better evaluation of scrotal swelling and its mechanism, radiological techniques, e.g., X-ray and C.T. scans are highly useful in detecting the presence of free air in the chest, abdomen and the scrotum.[4,12]

In cases of blunt injuries to the trunk, establishing the mechanism of scrotal emphysema become difficult when subcutaneous emphysema over the thoracic and abdominal wall

is not present. We found blunt injury to the back of the chest and abdomen which caused pneumothorax and pneumomediastinum and further air reached to the scrotum via retroperitoneal route. The scrotum has potential space to accept subcutaneous and retroperitoneal air due to fine and elastic fascial layers in its wall. Another concern which could turn this finding less significant are decomposition changes. The early decomposition changes like color discoloration and gaseous distension usually appears after 1 to 2 days in an average temperate climate.[13] However, in the present case, external signs of decomposition were not evident as the body was kept in cold chamber and autopsy was conducted within 24 hours of the death.

The presence of air in the scrotum is an uncommon finding though the significance of this condition is considered low, especially in traumatic cases due to other more significant associated injuries. Clinicians and autopsy surgeons required to be aware of this condition especially in medico-legal cases as the relatives or police personnel might draw spurious conclusions of assault over the genitalia even when a different mechanism is involved.

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CASE REPORT

Loaded colon causing death: A case report

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Abstract

Colon can be loaded with faecal matter following acute or chronic constipation. Most of the time it can be relieved with medical or surgical interventions. Rarely does it produce complications due to perforation by impacted stool causing peritonitis and sepsis. Here we came across the case of a young female who is brought dead to casualty following vomiting and abdominal pain. The medico legal autopsy showed a hugely dilated colon loaded with faecal matter causing respiratory and cardiovascular compromise due to the pressure effect on thoracic structures. The cause for the constipation in this case was an imperforated anus at birth which was operated in childhood itself but was not cured completely. We could hardly get this kind of complication with faecal impaction from literature as there are very few reported cases.

Keywords

Loaded colon; Faecal impaction; Chronic constipation; Imperforate anus; Respiratory distress

Introduction

Faecal impaction is a well-known complication following constipation which can be acute or chronic. There are several risk factors for this condition. Inadequate fibre contents in diet and poor hydration status of the body can cause constipation. Elderly individuals are more prone for this. There was a study of geriatric wards in the United Kingdom showed that up to 42% of the old patients had faecal impaction.[1] Several medical and surgical conditions like hypothyroidism, stroke, spinal cord injury, various gastro intestinal malignancies, impacted foreign bodies, intestinal obstruction due to various reasons like intussusception, volvulus etc. can cause constipation. Various medications like opiate analgesics, calcium channel blockers, anti-cholinergic drugs, iron preparations, and antacids are also known to produce constipation.[2]

Constipation when continued for a few days can cause impacted faeces. A timely intervention either medically with laxatives or manually with enema can relieve the condition.The acute cases of impaction typically presenting with symptoms similar to those found in intestinal obstruction from any cause, including abdominal pain and distention, nausea, vomiting, and anorexia.[3] If not managed in time, complications such as stercoral ulceration, rectovaginal fistula, megacolon, and colonic perforation may result[2] .Underlying surgical pathology if any, should be corrected. There are few congenital malformations like imperforated anus which can cause constipation from birth itself. In our case this patient had this condition and she was operated at the age of 3 years. But she was not completely cured.

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Case history

A 21-year-old tribal woman was brought dead to casualty with history of vomiting, abdominal pain and abdominal distention. No records of previous treatment or detailed history were available from relatives. And hence the case was brought for medico legal autopsy. The autopsy showed a moderately built female with congested face and distended abdomen. Conjunctivae were suffused. There was an old surgical scar, transversely placed over left side of front of abdomen 14cm long and the inner end of which was 4 cm to the left of midline and 1.5 cm below the level of umbilicus (Figure 1). No other injuries were noted over the body. On opening abdomen, the ascending, transverse, descending and sigmoid segments of colon and the rectum were enormously distended with an average external diameter of 15cm, filling almost all of abdominal cavity (Figure 2). The other abdominal viscera were compressed. Small intestine loops were shrivelled and seen matted together. This loaded colon was seen pushing the thoracic cavity upwards and the diaphragm was seen at the 4th rib level. Entire thoracic organs were seen compressed tightly. Both lungs were collapsed with pincer contusions at the margins and subpleural haemorrhages on the surfaces. The heart was seen compressed between the anterior thoracic wall and diaphragm with the loaded colon underneath and was converted in to a flat structure (Figure 3). No free fluid was seen in pleural or pericardial cavity. Liver was seen pushed upwards into the right thoracic cavity. Pelvic organs including urinary bladder and genital organs were seen compressed. The relative anatomy of the pelvic region was not well demonstrable due to severe adhesions and soiling.

Figure 1: Distended abdomen with previous surgical scar

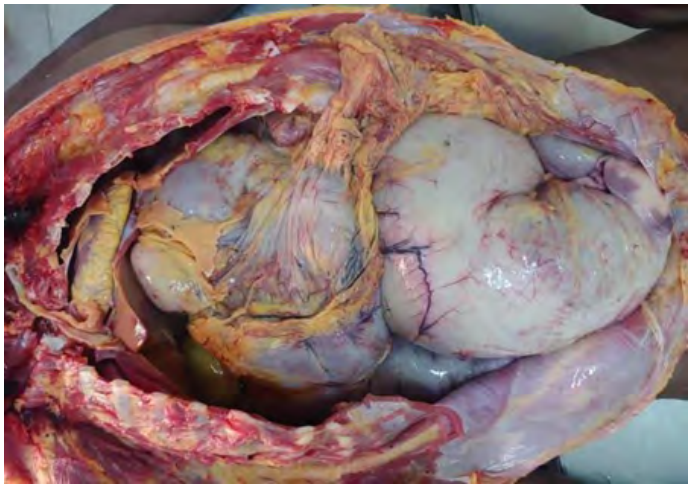

Figure 2: Distended large intestine filling abdominal and part of thoracic cavity

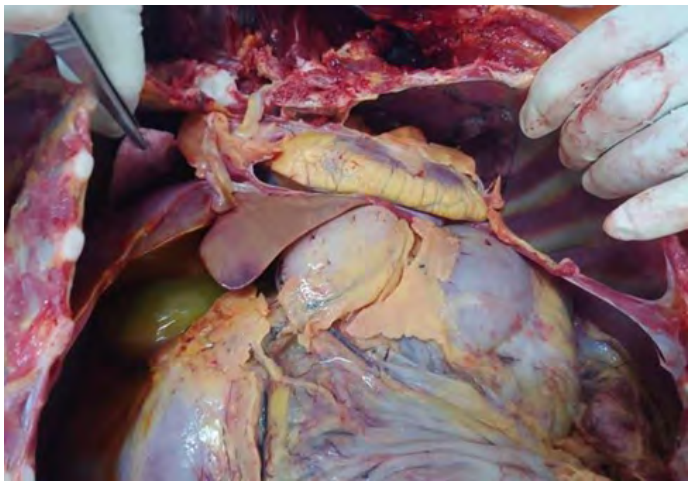

Figure 3: Compressed lungs and heart

This alarming finding made us to seek the clinical history. On detailed interaction the relatives revealed that the girl had imperforate anus since birth and there was some surgical intervention at the age of 3. In spite of that she had recurrent episodes of abdominal pain and constipation. Since she was from a tribal community of very low socio-economic status, she was not given adequate supportive care and none of the records of her previous surgery was available. Based on the post mortem findings we came to a conclusion that she died following cardio respiratory distress due to the pressure effect of loaded colon resulting from chronic constipation.

Discussion

This young female from a tribal community was brought dead to casualty. The relatives gave history of abdominal pain and distention. They couldn't fetch any treatment records. The medico legal autopsy had very surprising findings as mentioned above. A loaded colon can result from acute or chronic constipation. Usually, the patient presents with history of constipation and abdominal discomfort. Majority of case get cured by laxatives. Some cases require manual evacuation with enema. Complications can occur if the condition is not managed in time. In a systematic study, medical complications of faecal impaction was classified based on their anatomical and pathophysiological mechanism into three groups: Complications secondary to fecaloma effect on the intestinal wall (73.4 %), on the intestinal lumen (14 %) and on adjacent structures (12.6 %)[5]. Most common complication is the impaction of faeces which can result in acute abdomen in the form of abdominal pain, distention, nausea, vomiting and anorexia. The impaction can cause stercoral ulceration, fistula formation, megacolon and colonic rupture. Some patients can present with paradoxical diarrhoea and faecal incontinence. Secondary peritonitis following perforation can be life threatening as it can easily advance to sepsis. Large faecaloma causing intestinal obstruction and death is reported in literature.[6] In this case, the complication was relatively a rare one. It was solely due to the mass loaded in the colon following slow accumulation of faecal matter, producing pressure effects in the adjacent structures and even adjacent body cavity viz. the thorax. Patient had signs of asphyxia due to respiratory distress. We couldn't get similar case reported in the literature. This patient could have been saved if intervention was sought in time. Although faecal impaction is rarely fatal in this age group, she succumbed after suffering for nearly two decades. The surgery done in childhood for imperforate anus produced minor strictures which grew over the period of time could have produced further obstruction in the passage of stool. This slow accumulation is the reason for the expansion of the large intestine to such an extent.

Conclusion

Loaded colon and faecal impaction is commonly found in elderly patients secondary to various medical or surgical conditions. When it is present from childhood itself and was not given proper attention it can be fatal. We got a very rare mechanism of death as there was not much cases in the literature that of a loaded colon causing cardio respiratory distress and death. Let this case be an eye opener to the medical fraternity.

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CASE REPORT

Disclosure of a gunshot wound to the cranium on the basis of bone beveling and fracture pattern in a death alleged from railway track accident – A mystery unveiled

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Abstract
Misinterpretation and distortion of gunshot wounds to the head due to mutilation and disfigurement are not uncommon in forensic practice and they can wrongly designate the circumstances of death. The primary challenge in such cases is to approximate the bone fragments within the skull's anatomic silhouette so that the entry and exit sites created by the projectile can be correctly reconstructed. This is not an invariably easy task and is frequently accompanied by the fragmentation of the skull not only by the trauma itself but also due to taphonomic changes such as putrefaction and skeletonization. The soft tissues may be altered considerably by such processes while the fractured portions of the skull may not be available simultaneously due to scavenging, dispersal, or incomplete recovery. However, a proper understanding of the fracture mechanism in relation to ballistic trauma, especially the findings characterizing beveling over the projectile impact sites as well as along the relief fractures, may bring fruitful results even in highly challenging situations. A putrefied corpse belonging to a young, unknown male was found amongst bushes, in the vicinity of a railway track and alleged to die by blunt trauma sustained in a railway accident. A careful reconstruction of the available skull fragments however revealed fracture patterns and beveling typical of ballistic trauma. A preliminary evident railway track accident was ruled out by a scrupulous autopsy and crime scene details that surprisingly turned out to be a gunshot injury.

Keywords
Ballistic; Gunshot; Wound; Fracture; Beveling

Introduction

Accurate fracture interpretation is essential for locating the impact sites, establishing the number and sequence of blows, and to identify the characteristics of the object responsible for an injury. [1] While the signatures of sharp trauma are frequently evident as cuts and clefts over the bones thereby linking the injury to the likely weapon, the indicators of blunt force and ballistics trauma tend to be less discriminatory, leading to difficulties with the diagnosis of mechanism of injury. [2] This is particularly true with skeletonized remains where a correlation of skeletal trauma with soft tissue is often not possible.[3] Furthermore, blunt force and ballistics trauma have been explained to a great detail within forensic literature, but only a few studies have attempted to distinguish them. [1,2,4]

In the cases involving fragmentation and defects over the skull accompanied with incomplete recovery of the missing bone fragments, an interpretation of the fracture pattern and thereafter deducing an opinion over the cause of death may pose a great challenge.

In the present case, a putrefied unidentified dead body belonging to a young adult male was discovered in the bushes within vicinity of a railway track. A preliminary evident blunt cranial trauma from railway accident turned out to be a gunshot wound during autopsy.

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Case Details

Crime scene details

The present case belongs to the dead body of a young male individual with unknown identity. Purportedly, the body was found in the bushes, a few meters away from a railway line situated on the outskirts of a village, slightly distant from the main platform. The foul odor and appearances typical of bloating putrefaction were apparent on the first inspection by the police. The body was lying prone, showing a wide gaping wound defect over the left frontal region of head. A large area of V-shaped depression and deformation of the left side of skull was visible above temporal region. Two pale appearing soft tissue irregularities, one elongated and another roundish were faintly visible over top of the scalp (Figure 1). Facial features were not identifiable on account of putrefactive changes and the wound defect.

The *prima facie* appearances of the scene were suspicious of a dumped corpse. Furthermore, the dead body was lying not less than 20 to 30 meters away from the railway line. The apparent cause of death was suggested as “railway track accident” by the police. The dead body was taken to the local district hospital where it was kept for additional 72 hours (3 days) in hope for a

successful identification (as per state police manual and guidelines). Sadly, the delay in autopsy caused further putrefaction and almost skeletonization of the upper half of the body, primarily from heavy maggot activity in hot summer (average temperature ~ 40^0C). The corpse was apparently placed in an open and roofless mortuary of local hospital.

All the efforts of identification were however unsuccessful and the dead body was referred to our department by the board of medical officers (clinicians and non-forensic specialists) on the grounds of putrefaction and inability to find out the cause of death, necessitating autopsy by the forensic medicine expert.

Autopsy findings

The clothes were received loosely in a polybag, matching to those already visible at the scene and were heavily smudged with maggots, foul smelling dark stains and peeled off epidermis all over. The head and thorax regions were almost skeletonized except for remnants of lace like decayed and parched soft tissues supporting the bones at places (Figure 2). The skull with mandible, cervical veretebrae, sternum, scapulae and clavicles were separated and loose while the thoracic vertebrae and ribs were loosely articulated and easily separable on mild traction. Intact left ear with a blackish avulsed and putrefied scalp tissue over right occipital-parietal region were present but without any hopeful findings. Furthermore, putrefied tissue remnants and tar-like viscid foul material was encasing the bones all over at places. Viscera were missing from the head, neck and thorax while dark trubid material, intermingled with maggots was filling the cranial and pleural cavities. The abdomen, pelvis and lower limbs were relatively well preserved and intact but with putrefied and darkened soft tissues. Penis and scrotum depicted gaseous distension. Postmortem scavenging and gnawing of soft tissues was present over right thigh and shoulder girdles, with both upper limbs disarticulated from the body while right humerus was exposed. The bones were free of any evidence of animal feeding.

Injury

The following injury was found over the skull:

A large circular defect of 13 cm x 10 cm was present over left side of the skull involving frontal, sphenoid and parietal regions. The anterior and posterior limitations of the defect were depicting inner table and outer table beveling over left supra-orbital and left parietal regions, respectively. One fissure fracture was radiating down through left orbital plate of anterior basal fossa passing via cribriform plate and sella turcica up to right petrous ridge apex where it was arrested while another small radiation could be seen just lateral to it, confined to the orbital plate. The arc shaped concentric fracture over left parietal region exhibited outer table beveling (Figure 3). Two linear fractures were radiating posteriorly from the concentric fracture region and arrested over sagittal and lambdoid sutures. An additional thin infarct like fracture could be seen radiating from the defect, just medial to the lower radiation fracture. Two skull fragments recovered from the remains were reconstructed over the defect (Figure 4): (1) one rectangular fragment comprising of a portion of left parietal bone, (2) a large dome shaped fragment, primarily comprising of left frontal bone. A thin linear fracture was radiating from middle of the inner concentric fracture and arrested onto the coronal suture anteriorly. Further findings worth noticing were:

a. An oblique and irregular left frontal entrance defect roughly measuring 9 cm x 3 cm, with an M-shaped area of external flaking/chipping superiorly (Figure 5). A single linear fracture was radiating from its left margin posteriorly and upward coursing through frontal-sphenoid -parietal regions which was then arced by the concentric fractures of rectangular fragment over parietal region. The inner margin of the rectangular fragment also depicted prominent outer table beveling, in addition to the similar beveling over parietal fracture of the parent skull (Figure 6).
b. A keyhole-like exit defect with complete external beveling was present over left anterior parietal region and posterior to bregma (Figure 6). A closer scrutiny of this keyhole-like defect depicted relative flattening and lessened external beveling over its posterior edge in comparison to rest of the lesion. A roughly wedge-shaped defect could be appreciated just anterior to the keyhole lesion and in continuum with the coronal suture and defect over frontal bone, with (common) external beveling over its posterior edge. An inca bone was present over anterior third of sagittal suture, just posterior to bregma and in continuity with the keyhole defect. The parietal bone's outer concentric fracture line was arrested at the lateral (sutural) edge of the inca bone.
c. A large semilunar defect, likely representing the missing portion of radiating fractures, was emanating from the medial aspect of entrance defect, coursing superior and laterally across the frontal bone up to the coronal suture over bregma and merging with a wedge-shaped defect over there. Frontal process of left zygomatic bone was fractured.

Evidence of blunt trauma was ruled out primarily on the basis of beveling appearances at entrance impact site (inner table beveling and outer table chipping/faking), external beveling over keyhole and wedge-shaped exit defects shaped as well as over concentric fractures' sites, and the direction of radiation fractures over the base and vault of the skull. Evidence of plastic deformation was largely missing over fractures margins,

as the skull fragments could be well placed and reconstructed within anatomical silhouette.

A thorough maceration and reconstruction of the skull was done to further relate the findings. The course of radiating fractures along with the appropriate bevels over entrance-exit and concentric fractures sites confirmed the wound to be a result of firearm injury (Figure 7).

The shot was directed from left to right, front to back and in a below-upward direction. The trajectory was further supported by the course of radiating fractures from frontal entrance site over base of skull as well as those emanating from outer parietal fracture's margins and arresting onto sagittal and lambdoid sutures. Evidence of at least one gunshot injury to the head was confirmed at autopsy.

No other relevant defects or fractures were found over the skull. Mandible and other facial bones were intact. Cervical vertebrae were intact. Toxicology results of viscera were negative. No injury to available viscera or injury to other bones was seen. Hyoid bone and laryngeal cartilages were intact and non-ossified. X ray examination did not reveal any foreign body or projectile. No ammunition was recovered from the body's recovery site which was probably a dumping site. District hospital's mortuary was washed and cleaned.

Figure 1: Dead body lying prone in the bushes: a maggot ridden area of soft tissue defect is present over left frontal scalp region along with deformation and large V-shaped depression of left side of the skull above left temporal region, two faintly visible soft tissue irregularities/defects are present over top of the scalp.

Figure 2: Autopsy appearances of the dead body, as received in the mortuary: advanced skeletonization along with bloating putrefaction and soft tissue scavenging is evident (occurred at local district hospital where the body was kept for additional 72 hours).

Figure 3: Lateral view of the defect showing an inner beveling over left supraorbital ridge while outer table beveling can be seen over the large arc shape concentric fracture of parietal bone: thin fissure like radiating fractures is extending from the left orbital plate over base of the skull, coursing medial and posteriorly.

Figure 4: Two loose skull fragments were well approximated over the parent skull: the posterior rectangular fragment was constituted by two concentric fractures arcing over the left radiating fracture. A semi-lunar defect in the middle of frontal bone and merging on to bregma was probably due to radiating fractures emanating from frontal entrance defect.

Figure 5: Irregular oblique defect of entrance wound over left frontal region (a small M shaped outer table flaking is visible superiorly), secondary fractures are radiating from its right as well as the left margins.

Figure 6: Outer table beveling of the inner concentric fracture over left parietal bone is apparent: keyhole shaped exit defect and a wedge-shaped defect with external beveling are visible.

Figure 7: Macerated and reconstructed skull showing the bullet's trajectory

Discussion

The ability to differentiate between sharp force, blunt force, and ballistic trauma allows for an indication of the events surrounding death.[2] The precise interpretation of ballistic trauma may be the only way to determine features essential to the cause and manner of death.[1] Beveling features in firearm shooting in the skull has been well described.[5-8] A bullet striking approximately perpendicular to the bones of the vault usually produces a circular entrance wound with internal bevel while during exiting the wound is externally beveled.[9] A slight to significant chipping or flaking off of outer table around the entrance defect may occur as well, which along with inner beveling may lead to an atypical appearance of the entrance defect.[10-12]

However, the impact sites may also be completely missing or altered on account of postmortem taphonomic modifications and the trauma itself.[2,3] In such rare instances where the impact site is absent or altered in blunt force or ballistics trauma, other techniques of fracture patterns must be employed.[1] In the present case, the M-shaped area of flaked off outer table over frontal bone lacking any plastic deformation, along with inner beveling, was depictive of a similar firearm entrance wound.[10-12]

Fracture mechanism and beveling in blunt and ballistic trauma

The mechanism complex of primary (impact)-secondary (radiating)-tertiary (concentric) fractures in relation to ballistic and blunt trauma is well known in forensic literature,[1,2,13-15] although only a few studies have attempted to distinguish them.[1,2,4,13] In this context, the outer table beveling over concentric fractures' sites has been exclusively known to ballistic trauma.

Hart examined the beveling direction of concentric fractures in the skulls of blunt force as well as ballistics trauma in order to differentiate the fracture mechanisms between the two.[2] On the basis of the fact that the bone breaks in a direction from tension to compression in an angled manner due to shearing.[1,16] the author showed that in blunt impacts, the concentric fractures demonstrate an aspect of internal beveling while in ballistic impacts, due to increased intra cranial pressure and up heaving of wedge-shaped bony plates, the concentric fractures are externally beveled. The study concluded that cranial concentric fractures associated with blunt force trauma are internally beveled, whereas concentric fractures resulting from ballistics trauma are externally beveled.[2]

According to Symes et al, concentric fractures in gunshot wounds always exhibit external bevel, regardless of whether the defect was due to the entrance or exit of the bullet.[13] Other authors have also given detailed accounts of fracture mechanism, especially in relation to beveling direction, in order to differentiate between the blunt force and gunshot trauma.[1,4] In general, the greater numbers of radiating and concentric fractures that appear in multiple levels suggest that the more kinetic energy was imparted to the bone upon impact.[13]

A case of gunshot injury in archeological context, which was diagnosed on the basis of concentric fracture beveling, has been described by Berryman and Haun.[4] The cranium in that case was incomplete and severely deformed on account of burial pressure. Many facial bones were missing. Apart from the typical entrance defect with its corresponding internal and concentric fractures' beveling, the exit wound that was initially suspected to be from blunt injury, was later attributed to the exit defect of the same gunshot injury, on the basis of concentric fracture's outer table beveling.[4]

In the present case, the presence of external beveling over the concentric fractures along with other fracture patterns did not leave any doubts to our confirmation.[1,2,4]

Phenomenon of arrested/interrupted beveling

It was also noticed in the present case that the keyhole-like exit defect was located over the concentric fracture line and its

posterior edge was slightly flat and perpendicular in comparison to other margins, thereby giving an appearance of arrested beveling. It is a known fact that the radiating and concentric fractures from a gunshot entrance wound form and travel at speeds greater than that of the bullet and can actually precede the bullet before it reaches to the opposite side of the vault. [9,17] Thus an exiting bullet may strike over one of these (preexisting) fracture lines before it finally leaves the cranial vault.[1,4,9] The resulting mechanism may lead to the phenomenon of interrupted beveling causing an atypical appearance of wounds over the skull. [9,17-19] Similar mechanism may also operate in case a bullet tends to impact a suture line.

The presence of interrupted beveling further helps in ascertaining the direction as well as the sequence of firing in cases involving multiple shots to the skull. [1,9,17] The radiating fractures from the exit wound may terminate in pre-existing radiating and concentric fractures. Furthermore, it is also proven that additional generations of concentric fractures may form at sites distant from the entrance wound even before the bullet finally exits the cranium.[9]

The enormous speed of formation of radial and concentric fractures along with cranial up heaving has been also related to the fact that by the time the bullet exits, these fractures may have already reached and formed at the far side of the bone thereby causing fragmentation of the exit area before the bullet impacts that surface.[9,20] The phenomenon has been additionally explained in postcranial skeleton such as femur, tibia and clavicle.[3,20]

Application of Puppe's rule

The posterior concentric fracture line in the present case had been arrested by the lateral (suture) edge of inca bone that was located over sagittal suture just posterior to bregma. It is a proven fact that the fractures radiating from the subsequent impact(s) are arrested by preexisting fractures from the previous impact(s). Madea and Staak used these rules to sequence gunshot wounds, and precisely illustrated this principle with two impact sites in a glass sheet.[17] The sequence mechanism was first identified in the early 1900s by the German forensic pathologist Puppe for blunt cranial trauma.[21] Rhine and Curran demonstrated the application of these principles in successfully sequencing three penetrating gunshot wounds to a cranium while Spitz used the same technique for multiple blunt trauma.[18,22]

In essence, energy from the second impact is dissipated into the crack of the first and does not advance beyond it.[1] Although, it is more common for high energy gunshot radiating fractures to meet the sutures, causing their diastasis and thereafter continuing to the other side of the skull, giving a stepped Z-shaped outline across the suture.

Recovery of bone defects and fractured segments

The incomplete recovery of bony portions in severely mutilating gunshot defects is not uncommon, on account of the fragmentation that ensues from high energy shots.[1,23] Large sections of bone may be absent, having completely fractured and displaced from the areas of secondary and concentric fractures.[23] In our case, the skull portions corresponding to the fracture defects were not available at autopsy, although an understanding of the fractures' pattern and mechanism was helpful in arriving at a sound conclusion.

Keyhole lesion in skull

After reconstruction of the skull, a relatively tangential projectile's trajectory was evident in the present case. This was also reflected by the keyhole-like defect at the exit site.[24] However the exact shape and dimensions of entrance defect could not be ascertained due to incomplete recovery of the bone fragments. The presence of complete beveling around exit keyhole defect as their diagnostic feature and in order to differentiate them from the entrance keyholes has been well described.[1,24,25] Recently, the occurrence of typical keyhole defects from non-tangential and perpendicular shots to the skull has been described in a case report that was further proved experimentally, seemingly creating doubts on an absolute relation of keyhole lesion with the direction of fire/angle of bullet strike.[26]

Relevance of bone's plastic deformation in blunt and ballistic trauma

Another finding worth consideration in our case was significant absence of plastic deformation around the fractures' margins. Both of the skull fragments could be easily approximated over the parent skull without difficulty. The margins of the fractures were free of any changes of blunt trauma such as crushing or bending. This can be explained from the fact that when a tremendous amount of energy is rapidly imparted to the bone, as happens in a high velocity projectile trauma with extensive fracturing and fragmentation of skull, it behaves as a brittle material and generally fractures with little or no plastic deformation.[1,4] Thereby, unlike vaults fractured by blunt trauma, vaults fractured by high-velocity gunshot trauma can be more accurately reconfigured.

The plastic deformation is a *sin qua non* of blunt force trauma due to its slow loading and low energy character that causes a bone to pass through phases of elastic and plastic deformation before final failure that has been explained through stress-strain curve of young's modulus of elasticity.[1,25]

Knapping with external flaking and beveling in blunt trauma

In this regard, it is worth mentioning here that the evidence of outer table beveling or flaking in context of blunt cranial trauma is also known, under the term “knapping”. In knapping, multiple blows to the same region of skull lead to delamination

along the edges of fractures along radiating and/or concentric fractures, which is caused by rubbing of the broken bone fragments during repeat blows.[1,27] Knapping however depicts significant plastic deformation due to repeated slow load trauma that ensues from such impacts.[28]

Furthermore, knapping is mostly confined to the localized segments of the skull involved in repeated blows while the concentric factures due to ballistic trauma depict fairly uniform external beveling throughout their course. Similarly, rare alterations in the beveling patterns have been described for ring fractures of the skull.[1] and a special execution method in human right contexts among prisoners, known as "Khmer rouge execution method" that involves infliction of massive blows over the basal occipital region of skull while the person is made to kneel and bent.[23]

Overall, in consideration with the circumstances of the case, external beveling along the concentric fracture margins is suggestive of either a ballistic trauma or in case of blunt trauma depicts multiple blows (at least two) along radiating fractures to the same region of skull with evident plastic deformation.[1,27,28]

A recent communication with the investigating officer of the case was made by the author to ascertain any progress in the case but the identification of the individual has not been successful till date. The inability to fulfill the first prerequisite of *corpus delicti* (i.e., the identification of the deceased) is halting the progress of the case.[29]

Conclusion

A proper understanding of bone trauma requires scrutiny of the interplay of multitude of elements involved in the fracture production. The precise interpretation of ballistic trauma with its simultaneous differentiation from blunt trauma and postmortem modifications may be the only mean to determine the features essential to ascertain the cause of death. In gunshot fatalities, a reconstruction of the events can be possible on the basis of a variety of autopsy and scene findings. Although the unfavorable factors such as putrefaction, burning or dumping of the body can make this very difficult but there may still be details present even in the skeletal remains. A sound and thorough understanding of trauma biomechanics is required to unveil an unprecedented finding. The bone may be the only available evidence.

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PERSPECTIVE

Compulsory Rotating Internship Regulations Draft, 2021: A long-needed boost for medico-legal training

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The internship is a phase of training wherein a medical graduate will acquire the skills and competencies for medical and health care practice under supervision in preparation for independent, unsupervised primary care. The learning methods and modalities have to be initiated and inculcated during the M.B.B.S. course, with a larger number of hands-on sessions preceding actual clinical training. Currently doctors after graduation either join government service or go for private practice, or proceed for postgraduation/further studies. These medical graduates are mostly not exposed to any training on medicolegal issues during their internship which can have serious consequences in their practice of medicine. [1,2]

As the population of India is increasing, the number of medicolegal cases in hospitals is rising. No branch of modern medicine is exempted from medicolegal problems and cases. So good training in medicolegal cases is a dire need for the current M.B.B.S. internship training program. A doctor in a primary care setting has to deal with numerous medicolegal cases such as autopsies, reporting injuries, sexual assault victim examination, examination of drunkenness, etc.[3]. He must have good exposure to a significant number of medicolegal cases in his internship training so that he does not deviate from standard forensic practices to cause a miscarriage of justice.[4]

The previous internship schedule "Regulation on Graduate Medical Education (Amendment) Act, 2008" vide gazette amendment notification released on 20.10.2008[5], has kept forensic medicine as elective posting, one among the six electives for 15 days duration. This left a vacuum in medicolegal training for the freshly graduated students who were entering into the uncharted territory of a professional life without much first-hand knowledge and experience in medicolegal cases; which is a big deficit on the internship training part.

The internship period is critical to acquiring key skills for the practice of medicine. Presently the internship program is focused primarily on the clinical aspects while medico-legal aspects are often ignored during the training. National Medical Commission (NMC) has recently drafted the Compulsory Rotatory Internship Regulations Draft, 2021. [6] The draft has incorporated FMT under mandatory exclusive posting for a week. Thus, enabling interns to receive the supervised training solely devoted to medicolegal cases.

The specific objectives of the internship training program have been defined by NMC for FMT: -

1. An intern must have observed a medico-legal autopsy/ post-mortem.
2. Documentation and certification of trauma.
3. Identifying and documenting medico-legal problems in a hospital and general practice.
4. Legal documentation related to emergency cases. e.g.: Diagnosing and managing with competence basic poisoning conditions in the community.
5. Diagnosing and managing with competence and documentation in cases of sexual assault.
6. Establishing communication in medico-legal cases with police, public health authorities, other concerned departments, etc.

The proposed draft has addressed this problem to a great extent. This is a welcome step towards the recognition of medicolegal training to freshly graduated doctors. This draft would create pressure on the majority of private medical institutes to adopt strategies to enhance the medico-legal training of interns. Thus, specific interventions like collaborating with local government hospitals would be needed so that students can be posted there for training in MLC cases/autopsies on a rotational basis. All medical colleges across the country will need to develop an intern training program that lists all the essential certifiable procedural skills for forensic medicine posting as per the guidelines elaborated in the draft.

Knowledge of forensic medicine should not be restricted to mere facts and figures. The introduction of mandatory posting in FMT can broaden the perspectives of interns regarding medicolegal work. Hence, based on the Compulsory Rotatory Internship Regulations, 2021 the essence and importance of medico-legal work can be inculcated in budding doctors. However, covering all cases in the duration of mere 7 days would be challenging. In conclusion, we hope that this draft should be welcomed. We also propose increasing the duration to 15 days so that adequate medicolegal training can be imparted to the graduating students.

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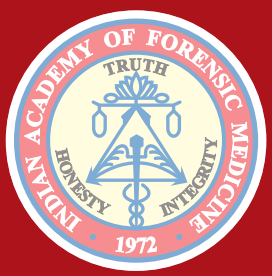
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